

Interborough Rapid Transit System (Original Line)
New York City (Manhattan & Bronx Boroughs)
New York County
New York

HAER No. NY-122

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HISTORIC AMERICAN ENGINEERING RECORD

INTERBOROUGH RAPID TRANSIT SUBWAY (ORIGINAL LINE)

NY-122

Location: New York City, New York
UTM: (Indeterminable)
Quad: Brooklyn, Central Park

Date of Construction: 1900-1904

Present Owner: City of New York

Significance: The IRT was New York City's first subway.

Historians: Wallace B. Katz, "The New York Rapid Transit Decision of 1900: Economy, Society, Politics", pp. 2-144.

Clifton Hood, "The Impact of the IRT on New York City", pp. 145-206.

Charles Scott, "Design and Construction of the IRT: Civil Engineering", pp. 207-282.

Barbara Kimmelman, "Design and Construction of the IRT: Electrical Engineering," pp. 283-364.

David J. Framberger, "Architectural Designs for New York's First Subway", pp. 365-412.

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HISTORIC AMERICAN ENGINEERING RECORD
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"THE NEW YORK RAPID TRANSIT DECISION OF 1900:
ECONOMY, SOCIETY, POLITICS"

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PROLOGUE

Construction of the first subway in New York City, the Interborough Rapid Transit underground railway or IRT, was officially begun on March 24, 1900 and completed, ahead of schedule, in late October, 1904. The assembled dignitaries -- one incumbent and one former mayor, other city officials, the Board of Rapid Transit Commissioners and its Chief Engineer and legal counsels, the subway contractor, and financier behind the IRT company -- who delivered speeches at the ceremony at City Hall marking the opening of the subway on October 27, 1904, rarely alluded to the past history of rapid transit of New York. They came to celebrate the fruition of great plans rather than to recall their frustration. Yet all of these men were old enough to remember many earlier subway projects that had failed. And some of them were sufficiently on in years to recall a city which lacked either elevated or underground railways, and in which the only available means of transportation other than foot from one end of a very long island to another was by means of private carriage, stagecoach, omnibus, or horse-car trolley. These same were unlikely to forget that this first subway was a hard won achievement, and that even five years before its opening, it had seemed a plan that might, for want of public funds or private capital, support from politicians, and sustained public interest, remain, as so often in the past, an unrealizable dream. Nor could they fail to remember that there were men seated on the platform beside them who had opposed, delayed, or, at the very least, remained indifferent to the enterprise to which they had devoted so much time, patient effort, skill, and, in one notable instance, almost an entire professional career. They perhaps chose not to recall their own failings and mistakes, but years of stalemate and frustration had revealed them nonetheless: indecision, ambivalence about their own proposals, disagreement among themselves about both principles and strategy, the inability, for complex reasons relating to their class prejudices and ideology, to mobilize public support for their cause.

In the end a combination of good luck and great need had assured the triumph of their project. Victory worked to confirm their proud sense of themselves as virtuous men, citizens of large interest and good will who had labored hard and well for the public weal. In the sunny, brisk atmosphere of a late fall afternoon in New York, resplendent in great coats, full-dress morning attire, and top hats, they could thus afford to overlook an unhappy past and speak instead of the greatness of their city and, because of the subway which their vision and energies had helped to effect, its yet greater destiny to come.

Belief in the inherent greatness, indeed the imperial stature of their city was in these men's minds tied to the creation of a comprehensive subway system. For them a rapid transit underground railroad was a panacea providing an easy solution to a variety of political, social, and economic problems that threatened New York's preeminence at home and abroad.

Uppermost in their minds was a political problem. In the nineteenth century New York grew from an oversized seaport town² into a giant industrial and commercial metropolis -³ the largest city in the United States and the second city in the world. In the course of the city's metamorphosis from town to metropolis, the native business elite that had controlled New York's politics since revolutionary times lost ground to new political leaders drawn from the immigrant groups, particularly the Irish, who swelled the city's population in the first half of the century. With Tammany Hall, the historic center of New York's Democracy, as their seat of power, these new leaders gave the city a government that functioned splendidly to serve a broad spectrum of special interests.⁴ Tammany became a byword for bossism, corruption, payroll padding, and favoritism. Perhaps more important, Tammany and a substantial part of the business community were mutually tolerant of each other's foibles. The business leadership acquiesced in and sometimes profited from corruption. Tammany acquiesced in and sometimes profited from a form of laissez-faire capitalism that was indifferent to the larger needs of the public. By the turn of the century, however, New York had become too large and complex a city to afford this state of affairs. The city required efficient and active government and officials whose first concern was not political patronage but rather the provision of urgently needed public works and services. The native business elite attempted to regain control of the city's of a number of great public decisions,⁵ whose management, in the elite's opinion, could not safely be entrusted to Tammany. Of these, the rapid transit subway decision was one of the most important.

The political problem of Tammany corruption related to a social problem. The increase in New York's population, particularly in the period 1860-1900, was largely due to immigration from the poorest, most backward, rural areas of Southern, Central, and Eastern Europe.⁶ The new immigrants customarily settled and tended to remain in the densely population and overcrowded areas of the lower East Side of Manhattan, where they found work; ghetto comradeship with both new and older immigrants from their native land; and help of various kinds from Tammany politicians who asked no questions when exchanging favors for votes.⁷ In the view of the patrician elite who led the fight for the subway, the squalid conditions of life in these ghetto slums spawned poverty, crime, and disease; reinforced the newcomers in values, modes of conduct, and traditions that prevented their integration into American life; and, most significant, enabled an inadequate, inefficient, and corrupt system of boss rule to preserve its hold on city politics, thereby precluding the creation of necessary public improvements and services.

In lieu of higher wages, which depressed times⁸ and the elite's adamant belief in a high profit incentive for capital rendered inconceivable, and in the absence of a considered policy of zoning, slum clearance, and tenement-house reform,⁹ the patricians envisioned but one solution for both the political problem of bossism and the social problem of immigrant slums. Rapid transit -- mechanized high speed trains running on tracks separate from the street, providing cheap, quick transportation from the Battery to lower Westchester -- would alone foster the dispersion of the immigrant population to the relatively undeveloped northern part of the city. In these more wholesome surroundings the immigrant would undergo a remarkable transformation. Liberated, as it were, from the prison of the ghetto with its bad influences and unhealthy atmosphere, he and his family would slowly become more like other -- that is, native -- New Yorkers, and, more important, would soon realize that the bosses who controlled city politics were not his friends but rather enemies of his own and the public's good.

New York was also beset by serious economic problems in the late nineteenth century, and these, like its political and social problems, demanded resolution if the city was to sustain its preeminent stature in both the nation and the world. In the early 1800's, because of its natural and splendid Atlantic port, its position as the nation's first major railroad terminus, and its accessibility as a market via inland waterways and then through its first great public "improvement," the Erie Canal,¹⁰ New York had unquestionably reigned supreme as the principal commercial city of the nation. In the last quarter of the century, however, New York was faced with potential rivals for its first-place rank. In the Northeast were Philadelphia, Baltimore, and, to a lesser but still worrisome extent, Boston, all of which, precisely in the effort to equalize their competition vis-a-vis New York, had been favored by federal port and railroad policy.¹¹ And in the Midwest was Chicago, a city which since 1850 had grown with astonishing rapidity.¹² By virtue of its role as a market for the agricultural wealth of its region and as the hub of a newly completed trans-continental railroad system, Chicago posed the greatest threat to New York's commercial supremacy.

But competition with these cities was not in itself the problem that most perturbed prescient New Yorkers of the time. What concerned them was New York's internal economic ills -- overdeveloped for both business and residential purposes in lower Manhattan, and underdevelopment in upper Manhattan, resulting in high taxes, an imbalance in real estate values, downtown traffic congestion that adversely affected retail and wholesale commerce, and a general want of amenity and convenience. Again, there was one simple solution that would deal with such problems. All of them were at least in part the consequence of the lack of adequate rapid transit, and would, accordingly, be substantially if not wholly remedied with the construction of a rapid transit underground railroad.

It should come as no surprise, then, that the opening of the first subway in New York represented for its partisans an occasion for self-congratulation and rejoicing. The IRT signified something more than the achievement of a great civic enterprise. Its realization was seen as a victory for good government, social reform, economic stability and growth, and, last but not least, a guarantee of the continued greatness of the Empire City.

Sanguine expectations of the subway such as these were bound to prove illusory, as the report on the impact of the IRT at the end of this study will show. For the urban historian, however, these expectations are no less interesting or important because they were unfounded. Indeed, because the first subway was perceived as an answer to virtually the totality of New York's most insistent needs, its genesis provides a particular case by means of which the historian can understand the totality of the urban life of New York in the late nineteenth century. The IRT, in and of itself, was a considerable achievement -- precisely how considerable, in light of its time and place and from the perspective of the history of technology, subsequent technical studies in this volume will assess. Here, however, in telling the story of the origins of the IRT -- how the demand for a rapid transit underground railway developed and made itself felt, how and why its realization was delayed, opposed, obstructed, and how the subway was finally achieved -- one is concerned with something different in kind from the conventional history of a great "improvement." In charting the origins of the IRT one confronts the history of a metropolis coming to grips both with the manifold problems of its growth in the nineteenth century, and with its political, social, and economic fate in the twentieth century.

FOOTNOTES

THE NEW YORK RAPID TRANSIT DECISION OF 1900: ECONOMY, SOCIETY, POLITICS

PROLOGUE

- ¹ Though ground was broken for the new subway on March 24, 1900, actual construction lagged for several months while staff was being recruited. When operation of the subway began in October 1904 the IRT was complete only from City Hall on the south to 145th Street and Broadway on the West Side. See James Blaine Walker, Fifty Years of Rapid Transit 1864-1917 (New York: Law Printing Company, 1918), pp. 172, 186.
- ² Robert G. Albion, The Rise of New York Port 1815-1860 (New York: Charles Scribner's Sons, 1939); Constance McLaughlin Green, American Cities in the Growth of the Nation (New York: Harper and Row, 1965), pp. 6-9.; George Rogers Taylor, "The Beginnings of Mass Transportation in Urban America: Part I," Smithsonian Journal of History, I, 2 (1966), 35-50.
- ³ Eric E. Lampard, "The Urbanizing World," in H.J. Dyos and Michael Wolff, eds., The Victorian City. Images and Realities, 2 vols. (London: Routledge and Kegan Paul, 1973), I, 9. (hereafter cited as The Victorian City).; Adna Ferrin Weber, The Growth of Cities in the Nineteenth Century: A Study in Statistics (Ithaca, New York: Cornell University Press, 1963), pp. 20-154.; Ira Rosenwaike, Population History of New York City (Syracuse, New York: Syracuse University Press, 1972), pp. 55-59.
- ⁴ Robert K. Merton, "Manifest and Latent Functions," Social Theory and Social Structure (Glencoe, Illinois: The Free Press, 1964), pp. 70-82.; Eric McKittrick, "The Study of Corruption," Political Science Quarterly, LXXII (December 1957), 502-514.; Samuel P. Hays, "The Politics of Reform in Municipal Government in the Progressive Era," Pacific Northwest Quarterly, LV (October 1964), 157-169.; John D. Buenker, Urban Liberalism and Progressive Reform (New York: Norton, 1978), pp. 1-41.; Joseph J. Huthmacher, "Urban Liberalism and the Age of Reform," Mississippi Valley Historical Review, XLIV (September 1962), 231-241.
- ⁵ Buenker, Urban Liberalism, pp. 25-32. See especially, David Conrad Hammack, "Participation in Major Decisions in New York City, 1890-1900: The Creation of Greater New York and the Centralization of the Public School System" (Ph.D. diss., Columbia University, 1973), pp. 5-8, 9-112. Though Hammack treats the rapid transit decision only in passing, it is one of the decisions to which his general thesis is meant to apply.
- ⁶ See Appendix Table 2 in Moses Rischin, The Promised City: New York's Jews 1870-1914 (New York: Harper and Row, 1970), p. 271.; Rosenwaike, Population History, pp. 67-81..
- ⁷ Merton, "Manifest and Latent Functions," pp. 74-75.
- ⁸ Rendigs Fels, American Business Cycles 1865-1897 (Chapel Hill, North Carolina: University of North Carolina Press, 1959), Chs. X-XII.; Charles Hoffman, The Depression of the Nineties: An Economic History (Westport, Connecticut: Greenwood Press, 1970).; Samuel Rezneck,

"Unemployment, Unrest, and Relief in the United States During the Depression of 1893-1897," Journal of Political Economy, LXI (August 1953), 329-331. The Depressions of 1873-1879 and 1893-1897 provided one reason among many for the reluctance of capital to invest in rapid transit construction in New York. The entire period 1873-1897 was characterized by a slackening rate of profit in the capitalist nations of Europe and North America, caused by the generalization of machine-made machines, or by what Marxist economists describe as the increasing "organic composition of capital." For a broader view of the long-wave cycle of world-wide depression in the late nineteenth century, see Ernest Mandel, Late Capitalism (New York: Schocken, 1978), pp. 108-146. For the social and especially the political ramifications on New York of the 1893-1897 depression, see Samuel T. McSeveney, The Politics of Depression: Political Behavior in the Northeast 1893-1896 (New York: Oxford University Press, 1972), pp. 3-72.

- 9 As Roy Lubove, The Progressives and the Slums: Tenement House Reform in New York City 1890-1917 (Pittsburgh, Pennsylvania: University of Pittsburgh Press, 1962), pp. 1-150., makes clear, neither zoning, tenement house reform, nor slum clearance were considered primary objectives by reformers in the period before World War I. Though there were important attempts to improve tenement housing and to regulate slum landlords (especially the New York Tenement House Committees of 1894 and 1900), most Progressives agreed with Lawrence Veiller, the celebrated tenement house reformer, in believing that the simplest and best solution to the slum problem was urban decentralization or dispersal of the slum population to the suburbs. This relates to the fact that the mass transportation problem of the late nineteenth century had to do with the problem of decreasing urban density, whereas today's mass transportation issue revolves around the question of urban mobility in the midst of urban-suburban sprawl. For more on the question of urban density and the desirability of suburban dispersal of the slum population, see A.F. Weber, Growth of Cities, pp. 474-475., and Adna Ferrin Weber, "Rapid Transit and the Housing Question," Municipal Affairs, VI, 3 (Fall 1902), 409-417.
- 10 Julius Rubin, "An Innovating Public Improvement: the Erie Canal," in Carter Goodrich, ed., Canals and American Economic Development (New York: Columbia University Press, 1961), pp. 15-66.
- 11 In the period 1865-1880 the Interstate Commerce Commission established freight rates favoring Boston, Philadelphia, Baltimore, Newport News and Norfolk, Virginia as against New York. See James L. Bahret, "The Growth of New York and its Suburbs since 1790," The Scientific Monthly, XI, 5 (November 1920), 404-415.
- 12 C.M. Green, American Cities, pp. 100-128.; Weber, Growth of Cities, p. 20.; Bahret, "Growth of New York," p. 413.; Lampard, "Urbanizing World," I, 9. Chicago was the "shock" city of the nineteenth century. In 1840 its population was approximately 5,000; in 1850, 30,000; in 1860, 110,000; in 1870, about 300,000; in 1880, 500,000; in 1890, 1,100,000; and in 1900, 1,700,000. See Bayard Still, Urban America: A History With Documents (Boston: Little, Brown, and Company, 1974), pp. 79, 210.

PART I

The construction of the IRT was the culmination of a thirty-year struggle for improved mass transportation in New York. The story of its origins is inseparable from the larger context of the history of rapid transit.

The need for rapid transit was sorely felt and strongly expressed in New York as early as 1865. By this date, which marked not only the end of the Civil War but also the completion in London of the first subway in the world,¹ the city had already undergone a transformation that would set the pattern for its development in the next thirty years, and that would also require mass transportation more adequate than ferries, omnibuses, horse-driven railways, and commuter railroads could provide.

Since the beginning of the nineteenth century a great change in number -- the expansion of trade, finance, and industry, and massive immigration from Europe -- had gradually produced in New York an even greater change in form. It was no longer a city in which the homes and businesses of its inhabitants were indiscriminately and compactly huddled around a magnificent natural harbor.² It was a very large if not yet giant city whose character was both enhanced and marred by the effects of rapid and uneven growth. It was a city replete with all the signs and symbols of "advanced" nineteenth-century urban development: a centralized and specialized business district; seaports, fashionable, and newly-built residences for the rich and middle classes, rigidly separated according to degree of wealth and social status; prosperous and fast growing suburbs. And it was also a city with problems resulting from and commensurate with its new size and stature: overcrowded and unhealthy slums, adjacent to or stuck within the interstices of the business center, existing in symbiotic relation³ with its new suburbs to the east and west across the two rivers; mile upon mile of undeveloped or underdeveloped land to the north of Manhattan Island, unpeopled save for the occasional farmer or squatter.

New Yorkers of the time understood that innovations in public transit were responsible for both the virtues and defects of their city's development. Without the existing modes of urban transport, its size in 1865 would have been inconceivable, and its spatial pattern inexplicable. But as most New Yorkers also understood, without considerable improvement in the extant modes of mass transportation -- without, that is, a rapid transit system -- New York after 1865 would suffer from the consequences of its own sudden growth.

In New York, however, the demand for rapid transit did not at first result in subway construction. London's underground railroad, the Metropolitan, stimulated schemes galore for a similar project in New York, none of which were in the least successful. A number of men who made a careful study of the rapid transit question argued repeatedly over the course of thirty years that a subway system would best meet the city's economic and social needs. But subway construction was very expensive. Municipal

government in the latter half of the nineteenth century was weak and often corrupt, and lacked the power, the will, and the money to build a subway. Moreover, public transit decisions were customarily considered the province of private capital, and since capitalists objected to the cost and doubted the potential profitability of underground railroads, the stopgap solution of elevated railways was the one chosen for New York.

The elevated railways were envisaged as a temporary solution and they provided the city with temporary relief. Within ten years of the completion of the elevated system, these roads were already inadequate to the city's needs, having created more traffic than they could satisfactorily handle. By 1890 the demand for improved rapid transit had become synonymous with agitation for a subway, but the large capital investment in both the elevated railways and the newly consolidated surface railway system represented an obstacle that would frustrate and delay subway construction for another decade.

ii

In 1866 the New York State Senate appointed a committee of five members -- Senator Andrews, Low, and Cornell, Mayor Hoffman of New York City, and Alfred Craven, the Engineer of the Croton Board -- to meet during the Legislature's recess, and to consider and report back to the Senate on the means and modes by which the City could obtain a transit system to meet its needs.¹

Three points in the resolution establishing this committee are worthy of comment. First the resolution specified that the committee decide upon "the most advantageous and proper route or routes" which such a transit system should follow. The stipulation that the committee chart possible routes and choose the best one, represented, a departure from the usual procedure concerning urban transit in New York, where, as in many other American cities,² the choice of routes for mass transportation was customarily left to negotiations between the private interests involved -- the builders of the proposed railway or horsecar line, their competitors, and property owners whose right of way would be affected. Second, in naming the Engineer of the Croton Board, Alfred Craven, to the committee, the Senate not only assured that it would have benefit of expert advice, but also made implicit reference to an earlier New York tradition of public responsibility for large public projects, such as the Erie Canal on the Croton Aqueduct. Third, the resolution emphasized that the commissioners should consider only proposals "suited to the rapid transportation of passengers from the upper to the lower portion of the city," which was explicitly to recognize that the future growth of New York depended on the creation of a rapid transit system, a system with trains of cars rather than just one, and with tracks that were separated from normal street traffic -- in other words, either an elevated or underground railroad.

With Senator George H. Andrews presiding, the Committee met in New York during the last six months of 1866, at first gathering data for its deliberations and advertising for proposals along the lines laid down by the Senate resolution, then hearing testimony from advocates of various elevated and underground railway schemes,³ and then, in two final months, making and preparing its decisions for public reception. On January 31, 1867, it submitted its report to the Legislature.

The Committee's conclusions were in three respects unequivocal. It began by stating its objections to the existing modes of urban transport; it ruled out any extension of railways on the surface of the streets, whether horse-driven or steam-powered, arguing that "if every avenue lengthwise of the island were to be occupied at once by surface rails, the relief afforded thereby would not be adequate to the present requirements, and in three years' time the pressure with all its accompanying annoyances, inconveniences and dangers, would be as great as it is today⁴." In this, as will be seen, the Committee drew attention to an important point: that every enlargement or improvement of the street railway system, rather than relieving traffic, tended after an initial period of grace to create and in turn be overwhelmed by more of it. The Committee also ruled against a single elevated or underground line through the center of the city, because such a line would serve little purpose if, as it must, it stopped at Central Park.⁵ Most important, however, was its declaration in favor of underground railways as "the only speedy remedy for the present and prospective wants of the city of New York in the matter of safe, rapid, and cheap transportation of persons and property."⁶ The Committee proposed the construction of two underground lines, to run together from the Battery to City Hall Park, and from there branching out separately to the East and to the West Side of the City until the Harlem River.⁷

In other respects the Committee's conclusions were less than clear. Though all five members agreed that underground railways would provide the best solution to the City's transit problems, they were not certain as to the most suitable motive power for New York's subways. London's underground, the Metropolitan Railroad, was steam-powered. But the principal difference between it and what would be required for the proposed subways in New York was that it was a short, open-cut railroad that infrequently ran through tunnels, and the tunnels it did have were far less lengthy than the distance between the Battery and 14th Street, much less the distance from the Battery to the Harlem River. For New York, then, the Committee raised the possibility of a more experimental technology -- pneumatic propulsion -- which an 1864 Select Committee of the House of Lords had expressly vetoed in London.⁸

Again, though the Committee was presented with numerous underground railway proposals, one or two of which it might have chosen to recommend to the Senate, it refrained from doing so. Either the Committee had reservations about the feasibility -- financial or technological -- of all these schemes, which in effect cast doubt on its own recommendations, or, as James Blaine

Walker, an early historian of rapid transit, has suggested, it chose to let the proponents of rival schemes "fight it out before the Legislature,"⁹ which reveals much about the Committee's limited conception of its own powers and responsibilities.

The Committee did nonetheless recommend a specific transit proposal, which in the end constituted the one practical consequence of its activity. It suggested to the Senate that Charles Harvey, the investor and promoter of a cable-powered elevated railroad, be permitted to construct a small segment of his road as an experiment. But this recommendation, later implemented by the Senate, was all the more curious, inasmuch as the Committee also concluded that elevated railways "cannot be fully adapted to the transportation of freight, and have never been tested in any practical way so as to warrant an unconditional recommendation of them for transportation of passengers."¹⁰

The best and simplest comment on the work of the Senate Committee of 1866 was made some forty years later, in the "History of State Regulation in New York," prepared by another public body concerned with the question of urban mass transportation -- the Public Service Commission for the First District of New York. Without remarking on either the ambiguity of the 1866 Committee's work or the motives that might have conceivably determined so finally inconclusive a report, the Public Service Commission merely stated what was -- and what for almost thirty years would continue to be -- unfortunately true: "the above report was without practical result."¹¹

iii

Whatever the Committee's reservations about the technical or economic feasibility of an underground railroad, its decision to recommend subway construction was rooted in its understanding of the needs and problems of New York. Its work may have finally been "without practical result," but the "commercial, moral, and hygienic considerations" to which it referred in its conclusions, were invariably mentioned for nearly thirty years thereafter whenever the subject of rapid transit was raised.

New York's needs and problems, like the form of the city itself, did not change qualitatively over the course of the next thirty years. They merely grew larger, developed in a previously established direction, and became more apparent, hence more pressing. Demographic, real estate, and public transit statistics, newspapers and business journals, as well as the arguments set forth by advocates of one or another form of rapid transit, all demonstrate the real and perceived continuity of the city's needs and problems over three decades.

In June, 1894 the Real Estate Record and Builder's Guide, the highly literate organ of New York's real estate and construction interests, celebrated the twenty-fifth anniversary of its publication with one-hundred and forty-three page Supplement, entitled "A History of Real Estate, Building, and Architecture in New York City, 1868-1893."¹ As might be expected,

given the Record and Guide's advocacy of real estate interests, the agreement of this retrospective compendium of facts and figures about New York's development was directed to a single and simple end: to describe how the city had grown and prospered mightily in twenty-five years; and to indicate what would be required so that it would continue along the same lines in the twenty-five years to come.

There were three especially prominent points in this discussion. First, the period immediately following the Civil War marked a turning point in New York's history, for from that time on its destiny was "to be not only the chief city of the North, but the Metropolis of a reunited country. . . . As of old all roads led to Rome, so now in this Western world, all roads lead to New York."² Second, the present city, the Metropolis of 1893, was "in an extraordinarily full sense" the creation of the prior twenty-five years. In a quarter of a century the City had changed a great deal, indeed in terms of its physical appearance had followed a pattern that could first be discerned shortly before or soon after the Civil War, and that had since become progressively more apparent.³ The Record and Guide emphasized a third point, which was that the development of New York "beyond the limits of the Colonial City" had been "strictly controlled by the nature of . . . rapid transit facilities," adding, so as to be sure that its readers caught the point, "that the extent of the one has ever marked the boundary of the other."⁴ Of course regular readers of the Record and Guide hardly needed to be reminded of this fact. In twenty five years scarcely a weekly issue passed without some mention of rapid transit, and some dire warning from the editor, C.W. Sweet, of what fate would befall New York without improvement of its rapid transit system. Even as it celebrated its twenty-fifth anniversary, the Record and Guide's message remained the same: the City had grown, changed, and prospered, and would continue to do so, but notwithstanding the advent of elevated railways and the recent introduction of cable-powered streetcars, its rapid transit problem endured forever.

The trouble was that over the course of three decades New York's population had increased and was continuing to increase absolutely and at a rate far in excess of the City's capacity to house it adequately. The cause of this lamentable situation was that New York could only develop in one direction -- to the north -- and residential movement in that direction depended unfortunately on improved rapid transit, which was not forthcoming.

The phrase "pressure of population" assumes real meaning when one considers that by 1875 more than one million New Yorkers were crammed into the southern part of Manhattan Island below 59th Street, and, of that figure, more than half were crowded into the Island's southern tip below 14th Street. And by 1890, with the population up beyond the 1.5 million mark, and increasing at a more rapid rate than in the previous thirty years, the city was still virtually undeveloped to both the East and West above 125th Street.⁵ Even the Upper West Side, both slightly above and below 96th Street, was partially developed.⁶ There were simply too many New Yorkers in too

small a space, and without rapid transit there was little possibility of a change in this situation. One begins to understand, then, why throughout these three decades New Yorkers looked to rapid transit as the answer to their apparently never-ending problem with sheer number.

The problem of number is of course inexplicable without reference to New York's other great problem, its unique geographical limitations. Some cities, like London,⁷ were unconfined by geographical bounds and could develop in a haphazard fashion, scattered out in all directions. Other cities such as Paris were limited in their development by man-made boundaries -- until the middle of the nineteenth century, by walls⁸ -- but this in itself did not preclude a relatively uniform circular pattern of growth from the center of the city to the circumference formed by the wall. By contrast, Manhattan Island was a narrow strip of land, twelve miles long and one-half to two miles wide,⁹ bounded on one side by the East River, on the other side by the Hudson, and with the Atlantic Ocean at its tip. Accordingly, its spatial development and much of its traffic were limited to an obligatory south-north axis.

By 1860 the southern end of the Island, at least as far as 14th Street or Union Square, had been taken over by a specialized central business district, so that residences were pushed further to the north, a process which continued as the business center grew. Early modes of public transit -- stagecoaches, omnibuses, and horsecars -- had made this pattern possible, but without rapid transit the northern development of the city had to cease. No one, not even the rich and middle classes who conceivably could afford the pecuniary cost, could or would afford the cost in time and inconvenience involved in traveling long distances at slow speeds in jammed horsecars to and from the business center in the south and residences far to the north.

To some extent before¹⁰ and quite markedly after the Civil War, then, another pattern began to take shape. The very rich spared themselves a long ride by reserving the best areas in Manhattan within reasonably easy reach of the business center. Some of the rich and many of the middle classes -- according to the Record and Guide, all varieties of lower, middle, and upper-middle class¹¹ -- availed themselves of the nine ferries across the two rivers and left the city for greener pastures in Brooklyn, Long Island, and the towns of nearby New Jersey. The working poor, cut off from northern movement by the lack of quick cheap transport and by the residential area reserved for the rich, and unable to afford either the price of the ferries or homes in the suburbs, stayed where they already were, in the ever more densely concentrated sections of the lower half of the city, adjacent to or interspersed within the central business district. Meanwhile, vast tracts of land in the northern half of the city above 125th Street, including the territories of lower Westchester -- annexed in 1874, were left, as one writer put it, "to languish and depreciate in value."¹²

That the rich had reserved a substantial and choice part of Manhattan, the entire area adjoining Central Park, for their present and future residential development, was a fact perhaps first remarked upon by the Senate Committee of 1866. It not only discerned the new pattern as it was just taking shape, but also recognized the problem which would result from it, offering as well its own unfortunately aborted solution. The Committee perceived that the residential district reserved for the rich, which was virtually all of midtown Manhattan, constituted a barrier to the northern movement of the poor, which could only be overcome by rapid transit in the form of two underground railroad lines.

The Central Park, bounded on the South and North by 59th and 110th Streets, on the East by the Fifth Avenue and on the West by the Eighth Avenue . . . an area more than half a mile broad by more than two and a half miles long, . . . not only excluded from its boundaries all tenements, but all property within the area on either side of it extending nearly to the rivers and for some distance above and below the Park has advanced so enormously in value within the past six years as practically to exclude the laboring classes from residence in a district more than three miles long and extending nearly the whole width of the city. For a large population, then, this area on either side of the Park, unavailable for its greater portion for domiciles for the working classes, requires in effect to be traversed by some method affording rapid means of transit from the extreme upper to the lower portions of the city.¹³

Seven years later in 1873, after little substantial improvement of the rapid transit situation, the new pattern foreseen by the Committee was firmly established, and The New York Times, regretfully accepting its negative consequences, predicted that "New York will become a city of the very rich and poor, of those who can afford to stay and those who cannot leave."¹⁴ Two years later the Record and Guide, still hoping that rapid transit could forestall or definitively avert this pattern by equalizing land values, looked forward to a city in which "moderate prices for land all along the line from Fifty-ninth street to Yonkers" would foster "the introduction of a middle class between our millionaires and paupers."¹⁵

By 1877, however, the Record and Guide projected a different vision. Like the Times it saw no choice but to accept the prevailing pattern; unlike the Times it went a step further by rejoicing in it, deciding to make a silk purse of a sow's ear. It prophesized a future city with but two social classes -- rich and poor -- and three distinct "classes of property": one section in the lower third of Manhattan containing industry and wholesale commerce; one district in the middle of the Island given over to the fashionable retail trade; and one part of the city, the upper third, restricted to the elegant homes of the wealthy.¹⁶ And inasmuch as these three distinct

"classes of property" would "exhaust the available territory of the island proper," the Record and Guide foresaw no other alternative for the working classes but to seek their tenements -- "the inevitable dwellings of the poor" -- wherever they could best be found, "interwoven with and around these distinctive localities, in spots and gaps unsuited for the use of any of them."¹⁷

The Record and Guide, as one might assume of a journal that spoke for the interests of realtors, builders, and property owners, remained largely unconcerned about two problems that evoked dismay in other New Yorkers: the problem of the slums and the problem of suburban exodus. Throughout the late 1870's and 1880's, when the upper East and West Side above 59th Street were in the process of being built up, and when money for development further north was thus unavailable, the Record and Guide rarely discussed the slum problem in the Lower East Side. And on the few occasions when it did refer to tenement house reform its primary purpose was to berate "philanthropists" who wanted to destroy those structures, or prevent new ones from being built.¹⁸ Only when the area around Central Park and some parts of Harlem had been partially developed, and when real estate brokers started to think about the opportunities open to them through development of northern Manhattan and lower Westchester, did the Record and Guide change its tune. By 1890 it began to consider the problem of tenements, and the necessary connection between rapid transit and the dispersal of the slum population to "cleaner and fresher air" to the north.¹⁹ The Record and Guide was similarly indifferent to the problem of suburban exodus. It welcomes stimulation of the real estate and construction businesses from whatever quarter it might come, and houses built in Brooklyn, Hoboken, or Jersey City were better than no houses built at all. The Record and Guide's position on these two issues, however, provides curious illustration of the extent to which the defense of special interests can both mislead and enlighten. With respect to one issue -- the problem of the slums -- its attitude was callous and short-sighted; with regard to the other issue -- suburban exodus -- it was both astute and prophetic.

The problem of suburban exodus was far less grave than many New Yorkers thought, and would in time be definitively solved, as the Record and Guide first predicted,²⁰ by the consolidation of Manhattan with its Brooklyn and Long Island suburbs. Consolidation would not take place, however, until 1898, and in the 1860's and 1870's most New Yorkers failed even to imagine, much less promote it. They could not perceive that New York was fast emerging as the nation's first great metropolitan district,²¹ and that nearby cities and towns, if still politically autonomous, had already become socially and economically dependent on New York. Nor could they understand what to any contemporary statistician seems easily explained -- their city's declining ratio of population increase. New York's falling and Brooklyn and northern New Jersey's rising rates of growth were in accordance with statistical law: the larger the aggregate of population, the slower the rate of growth; the smaller the aggregate of population, the faster the rate of growth.²² New York's growth from 1820 to 1850 had, of course, defied this law; a rare occurrence owing to the construction of the Erie Canal and its effect on the city's commerce,²³ and an occurrence not to be repeated.

But New Yorkers of the late nineteenth century knew nothing of this law, and could hardly be expected to understand that their city's earlier rate of growth was only the exception that proved the rule. What they saw and, even more, what they feared, was a city losing population and tax revenue to its neighbors, a city whose rate of growth was declining while the size of adjacent areas rapidly increased, and a city whose development, in the absence of rapid transit, had been artificially and abruptly halted.

One writer, arguing in 1870 for rapid transit, observed a great difference between the New York of the first half and the New York of the second half of the century. In 1817 New Yorkers had been willing to take a risk in building the Erie Canal, and because of it they had captured the Western trade and surpassed their nearest rival, Philadelphia. But New Yorkers of the present were too timid to build an underground railway, and thus would soon lose out to Brooklyn -- in 1870 the third largest city in the United States.²⁴

The same writer was also worried about the potential development of New Jersey cities, which, as he clearly indicated, were growing at New York's expense because "the time required to travel from Harlem is over two hours, while that from Elizabeth, New Jersey, just twice the distance, is only fifty minutes."²⁵ The Times was similarly perturbed by the growth of Brooklyn and New Jersey. In an editorial of 1874 it pointed to the fact that Brooklyn's population had not only grown more rapidly than New York's, but also, at least during the period 1860-1870, had made an absolute gain slightly in excess of the city's. And Jersey City had nearly trebled and Hoboken more than doubled in population during the same decade.²⁶ "People have found," said the Times, "that a residence within two miles of Fulton Ferry, on the Brooklyn side, and a mile of Williamsburg Ferry is nearer to the lower portions of the City than a residence above Fifty-ninth Street. Jersey City and Hoboken are still nearer, and a traveler can reach any place within 17 miles of Jersey City in the time required to take him to Sixty-second street."²⁷

In a few years, however, the Record and Guide was proven right and the Times proven wrong. The exodus from New York to Brooklyn, Long Island, and New Jersey, did not wholly cease, but with the completion in Manhattan²⁰ of the elevated lines by the early 1880's, it did lessen considerably. More people at least than before could and did move north on Manhattan Island. This, together with massive immigration from Europe,²⁸ somewhat augmented the city's rate of growth, though it was never again as great as in the three decades prior to 1850. Other problems subsided or momentarily disappeared as well: the diminution of the middle-class population of the city, and the imbalance of land and real estate values.

The "els" were a stop-gap solution to the city's transit needs, but they provided at least temporary relief for some of its problems. No one, not the Record and Guide, nor the Times, nor the other newspapers except

The Sun, the house organ of the elevated company,³⁰ and least of all the passengers who rode the trains, was completely satisfied with the "els." Everyone complained of the way the elevated structures darkened and obstructed the streets, and, because of the smoke and cinders from their steam-powered engines, the way the trains dirtied the streets. Few were totally pleased by the elevated's service, its speed, or the routes that the four lines followed. Some, like the Record and Guide, lamented the cheap, flimsy, and impermanent character of the elevated structures themselves.³¹

Yet as early as 1880, the Record and Guide declared itself "not only friendly to the present elevated roads, but to all proposed ones," adding "they are worth not four times, but twenty times their cost to the owners of real estate and the people of this metropolis."³² Hardly any New Yorker would have taken issue with the judgment of the Record and Guide in its Supplement of 1894:

. . . it was in the years 1879-80 that New York came into full possession of its present rapid transit facilities, and to this fact probably more than to all others put together is due the activity in real estate and the increase in values that commenced in these years . . . it must also be acknowledge that the utilitarian service which they (-the "els") have rendered to the city has been enormous. The marvelous expansion of the metropolis northward within the last fifteen years is directly due to their assistance. In their absence New York as we know it today north of Fifty-ninth street is inconceivable.³³

The Times, too, in spite of its suspicion of the elevated company's management, joined the bandwagon, and lauded the "els" for the work they were doing in restoring a balanced social composition of the city. An editorial writer spoke of a middle-class return to New York, and of "new recruits" who "bring their neighborhood with them, and fill contiguous dwellings with reputable and congenial occupants."³⁴

Praise for the elevated roads also emanated from another and surprising source: from proponents of underground railway schemes who hoped and believed that the very success of the "els" would stimulate both the public and, more important, private capital to invest in still better, if more expensive, forms of rapid transit. For this reason subway advocates cited impressive statistics about the "els": how much they had cost; how much profit in relation to original cost they earned; how their passenger traffic had increased and how much more it could be expected to increase; how they had helped augment land and real estate values along their routes; how, by contrast, streets at great distance from their routes had suffered a loss of value; and how, by bringing a greater number of people from greater distances into the center of the city to shop and conduct business, they

had improved the commercial life of New York.³⁵ The main point, of course, was that the "els" had created most of the traffic that they handled. This was a true point as well. After an initial loss, passenger traffic on the surface railways had not decreased but increased because of the "els", profiting from the enormous short-distance spillover that the "els" created.³⁶ And if the elevated roads could achieve such success in a short time, then, or so the subway advocates argued, real long-distance and much faster transport -- underground railroads -- could do even better.

However, in one respect, which was never mentioned by those who praised the "els," these roads proved to be a failure. Even in the early 1880's, before bad management and the renaissance of old problems caused widespread public disenchantment with the "els," there was one problem, the slums in the lower East Side, which the elevated trains could neither solve nor alleviate, and for which, presumably, only a subway might provide relief.

Indeed insofar as the "els" generated a larger traffic moving to and from the central business district, which in turn prompted its expansion, their effect on the slums below 14th Street was counter-productive. For as the business center expanded, the area in which the working poor could live in close proximity to their work was further contracted. And with immigration increasing in the 1880's, this meant a slum problem even greater than twenty years before, when the Senate Committee had expressed special concern regarding the "moral considerations" that demanded a quick and adequate solution of the rapid transit problem.

Expansion of the business center would not of course have mattered, had the "els" managed the task which social reformers expected rapid transit to accomplish, the "dispersal" of a substantial portion of the slum population northward, into less crowded and "healthier" areas of the city.³⁷ But this they could and did not do. As Adna Ferrin Weber, the celebrated author of The Growth of Cities in the Nineteenth Century, indicated in 1899, the removal of the poor to the northern suburbs could not be achieved by cheap and rapid transit alone. It required as well higher wages, shorter working hours, and some method -- Weber suggested "associations for promoting the ownership of suburban homes by workingmen" -- by means of which the poor could afford to buy homes in the suburbs.³⁸

In the 1880's, the hey-day of the "els," none of these conditions prevailed. The "els" themselves were slow, or at least not fast enough to count as rapid transit for unskilled laborers obliged to work ten to twelve hours daily. One critic noted that the 6th Avenue line took twenty-three minutes to travel from the Battery to 23rd Street, and that the 3rd Avenue elevated road took forty-five minutes to go from South Ferry to 129th Street. None of the lines averaged better than twelve miles an hour after making from two to four stops per mile, which scarcely met the popular demand expressed in the slogan "From the Battery to Harlem in 15 minutes."³⁹ The "els" were also

too expensive. In 1875 fares had originally been set at ten cents between the Battery and 59th Street, and for the East Side lines fifteen cents and the West Side lines seventeen cents for the trip from the Battery to the Harlem River, with half-price "commission fares" during rush hours.⁴⁰ By 1886, a year in which the roads carried over 115 million passengers,⁴¹ fares were reduced to a standard five cents. But even this fare, given the extra cost of transfers to the street railways, was prohibitively costly for the tenement dweller of the lower East Side, who at best earned \$16 or \$17 and at worst \$8 or \$9 weekly, not counting periods of unemployment.⁴² Moreover, even had the immigrants of the lower East Side been able to spare time or money to travel on the elevated roads, they could not have afforded the price of either homes or apartments to the north. The very rise in land and real-estate values that the Record and Guide attributed to the creation of the "els," precluded working class settlement in the northern sections of the city.

All of the needs and problems requiring improved rapid transit were discussed in a remarkable pamphlet, written in 1884 by one underground railway proponent who refrained from praising the "els." His name was John Isaacs Davenport, a newspaperman, lawyer, political and social reformer, and as George Rogers Taylor has said, a subway advocate whose conclusions can be trusted.⁴³

Like almost all reformers of his time and social class, Davenport's concern with the problem of the slums, creditable as it was, belied an even greater anxiety, indeed a fear, about the possible effects on the moral, social, and political character of American life of the "social disease" of the slum. As someone who devoted much of his life to the study and control of political corruption,⁴⁴ Davenport perhaps saw in the immigrant slum dweller a potential voter too precisely suited to the needs and interests of Tammany Hall and the Tweed Ring. As the patrician descendant of a prominent Connecticut family, he was perhaps threatened by the lower-class and the foreign rather than native American moral deportment of the immigrant slum dweller. He was quick to see pathological social conditions -- poverty, crime, disease -- while failing to notice that these same slum dwellers resisted the worst effects of social deracination through strong kinship, religious, and political allegiances.⁴⁵ Again, in common with other reformers of his time, Davenport was perhaps too ready to find nothing of redeeming value in these slums, to miss whatever strength of character or simple vitality may have existed in this world.

All this helps to explain why he and most other patrician reformers were so eager to remove everyone from these slums, to disperse their population to the northern suburbs -- to Arcadia within easy reach of the city, the rus in urbe. Instead of the "dirt and confinement, the dreariness, ugliness, and vice of the poorer quarters of a great city," the erstwhile slum dweller would find in the suburbs "sunlight, fresh air, the sight of grass and trees," and his children "the opportunity for healthy moral and physical growth."⁴⁶ And this also explains why, while neglecting to consider the question of the wages or working hours of the poor, men like Davenport put so much store by the improvement of rapid transit. For by the late nineteenth century rapid transit

had become a panacea for the quick and easy abolition of all social evils. It promised a social reformation without class struggle, without sacrifice on the part of the employers or the propertied classes, and one achieved in such a way that men like Davenport would not have to relinquish or even question their sentimental belief in rural virtue, while nonetheless partaking of all the advantages -- wealth, culture, diversity -- of a city whose very existence represented its antithesis.⁴⁷

And yet, in spite of his ideology, Davenport made a very good argument for a rapid transit underground railroad. In part, this was because he filled his pamphlet with a multitude of facts and figures about slum life that one rarely found in the pages of the Record and Guide. He knew all about the beginnings of the tenement-house slum in the early nineteenth century. He described how old single-family dwellings were converted into "tenant houses" for three or more families, and how, once landlords discovered that these converted houses yielded substantial profit in rent, they began to erect new houses designed especially as tenements -- "buildings upon small lots, frequently two buildings, one in front and one in the rear of the lot, without the slightest attention being paid to the most simple and ordinary sanitary measures."⁴⁸ He also knew why these tenements were so quickly packed with the working-class and immigrant poor.

. . . there was nowhere the working portion of the community, and the poor, could go, but to the east side of the city. The utter absence of public means of conveyance, and the necessity of being within easy walking distance of their place of work, compelled the masses to reside in the lower wards while the greater value of property in the northern and western sections of the city forced them to the east side, which thus became, each year, more densely settled.⁴⁹

He cited statistics drawn from the Citizen's Association Council of Hygiene Report of 1864 and from other sources such as the Metropolitan Board of Health, which showed that the average density of population per acre in New York below the Harlem River was 110, surpassing even Paris and London.⁵⁰ Density in certain wards of the lower East Side -- the fourth, sixth, seventh, tenth, eleventh, thirteenth, fourteenth, and seventeenth, ranging from 233.6 to 432.3 persons per acre⁵¹ -- availed the working class and poor of "very little more ground space than is appropriated to the dead -- a distribution which is not less fatal than it is impartial."⁵² He cited mortality statistics to demonstrate that overcrowding and squalor were responsible for New York's high death rate, which was greater than any other American city's and higher even than that of the largest cities in Great Britain and France.⁵³ And referring to Dr. Stephen Smith, another social reformer and the first Commissioner of the Metropolitan Board of Health, Davenport concluded that there was only one solution for all these problems. Smith said it was fruitless to

remove the filth from the tenements; no amount of tenement-house regulation or reform would ever work.⁵⁴ What the situation required was the removal of the slum-dweller from the slum, and this could only be achieved by means of rapid transit.

All of Davenport's facts and figures were directed to the promotion of a subway. His thesis was both simple and true: that in New York public transit facilities always came too late to do any good. By the time they made their appearance -- he had in mind the horsecars in the 1850's, and the "els" in the 1870's and 1880's -- rising land values, a further expansion of the business center, and a new and even more massive stream of immigration rendered these "improvements" useless with respect to the problem of the slums in the lower East Side. In the year he wrote, 1884, a subway was urgently needed, not only because the elevated trains did not provide true rapid transit, but also because a subway, if not built now but later, would be ineffective. Time counted. If not in 1884, then certainly in a few years, speculators would begin to turn their attention from the upper West side and Harlem and hike up the price of land in the northernmost sections of Manhattan and the Bronx. Yet another wave of immigration would inundate the lower East Side. And the central business district, growing ever more crowded and congested, in part because of the traffic generated by the "els" and more efficiently powered streetcars, would further expand.

Davenport's argument is persuasive. Rapid transit was doubtless seen as a panacea. But if the opinions of contemporary reformers like Davenport are to be given any weight, then one must consider why each new form of public transit and as will be seen, both forms of rapid transit -- the subway as well as the elevated trains -- ultimately failed to achieve the ends that reformers and other interested parties expected of them. Davenport's argument provides an answer to this question. Public transit, rapid transit, came too late, long after it was needed, and long after it could or would do the most good. And if Davenport's thesis has some truth, then in answering one question it poses another: Why did it take so long for New York to build a subway, or, in other words, why was the Senate Committee Report of 1866 "without practical result?"

iv

In the period between 1864 and 1902 sixteen separate companies received charters from the State of New York to construct an underground railroad in Manhattan.¹ One of these, the New York City Rapid Transit Company, was organized in 1872 by Commodore Vanderbilt of the New York Central for the express purpose, not of building a subway, but of preventing anyone else from building one.² Another company, first chartered in 1868 as the Beach Pneumatic Transit Company, began its largely paper life³ as a plan for a pneumatically propelled freight railway. It changed its name in 1874 to the Broadway Underground Railway and became a subway plan for the carrying of passengers, then reappeared in 1885, still as a subway plan, under the

name of the Arcade Railway. Transfigured yet once more in 1897 as the New York Parcel Dispatch Company, a pneumatic railway, it finally passed into oblivion. Another proposed road, the New York City Central Underground Railway, first chartered in 1868, achieved a short-lived renaissance in 1880 as the New York Underground Railway Company. The Metropolitan Railway Company bears the distinction of putting forth in 1864 the first proposal for a subway in New York City's history. The New York District Railway, chartered at the end of 1885, is worthy of note because it was unsuccessfully promoted by two young men who subsequently made good -- William Barclay Parsons, later Chief Engineer of the Rapid Transit Commission that planned New York's first subway, and August Belmont, the financier whose firm, the Interborough Rapid Transit Company, chartered in 1902, finally did build the subway.

Regarding all of these subway schemes, save the last of course, there is something tragi-comical. They suggest a Victorian melodrama of the sort with which we are all familiar -- that is stories about charlatan promoters and naive investors, tales of great men, Dickens, U. S. Grant, Mark Twain, who go bankrupt after having sunk their money or their name in some failed speculation -- moral fables about men with big plans and high hopes who die penniless, alone, and mentally unsound. One is not surprised to discover that upon being retired by his Party from high office in 1884, Chester Alan Arthur, the twenty-first President of the United States, became the figure-head president of the Arcade Railway Company; or that the officials of the New York Central Underground Railway Company first bribed the legislature to obtain their franchise, then hawked their stock in one European capital after another in a futile attempt to secure investors, and finally wound up using their worthless charter in real estate speculations in Harlem and Westchester.⁴

Such stories as these form part of what might be called the folklore of nineteenth-century capitalist society -- the great age of entrepreneurs who made it and many more who did not. Nor are these stories irrelevant. The simple fact is that no subway was built or would ever be built in New York without private capital willing to build it.

There are many reasons why nineteenth-century American capitalists were reluctant to undertake the construction of a subway, but all these reasons can finally be reduced to an essential and obvious one: men with a stock of capital sufficiently large to build an underground railway were not convinced that it was or would ever become a profitable enterprise. The question to consider, then, is what led them to believe that a subway "wouldn't pay."

It was in London, after all, that capitalism was invented, and it was there, as well, that the first subway in the world, still unfinished, opened for business on 10 January 1863. A little more than a year before this date, the Times of London had noted that many English capitalists, like their American counterparts, had been skeptical about whether such a project

. . . even if it could be accomplished, would . . . pay. A subterranean railway under London was awfully suggestive of dark noisome tunnels, buried many fathoms deep beyond the reach of light or life; passages inhabited by rats, soaked with sewer drippings, and poisoned by the escape of gas mains. It seemed an insult to common sense to suppose that people who could travel as cheaply to the city on the outside of a Paddington 'bus would ever prefer, as a merely quicker medium, to be driven amid palpable darkness through the foul subsoil of London . . .⁵

But despite the difficult task of allaying public anxiety about underground travel and the gloomy predictions of financial failure, a number of English businessmen, several distinguished civil servants,⁶ the Corporation of the City of London,⁷ and a Parliamentary committee had nevertheless decided that to risk chances and a hard-headed business sense were both equally important elements of the entrepreneurial ethos. And as things turned out, the gamble paid off at least in the short run. Public fears about underground travel were overcome, and by 1868 the Metropolitan was carrying more than 27.5 million passengers a year, and paying a healthy dividend of from five to seven percent.⁸

In later years, to be sure, the Metropolitan did not do so well. After 1870 its dividend fell off or was only paid at the five percent rate from profits derived from its substantial surplus land holdings.⁹ And its sister road which soon became its rival, the Metropolitan District Railway, was never a profitable venture. This line, which began partial operation in 1868, suffered from having been built through some of the most expensive real estate in the world, and was, in consequence, burdened with numerous added and special costs.¹⁰ Both lines, moreover, ran into difficulty by quarreling rather than cooperating with each other. Their rivalry led them to overextend themselves by expanding into areas where local authorities and landowners, anxious to profit from the needs of the companies, made them pay for costly street improvements or imposed special conditions on their construction.

It can be said, then, that London provided a number of positive and negative precedents for the New York capitalist of the late 1860's or early 1870's, who may have been considering investment in a subway. To begin with, the profit ledger of the Metropolitan in its first seven years of operation offered him the encouragement of a sufficiently attractive financial incentive. Second, though the earnings of the London undergrounds were not in the long run as satisfactory as had first been expected, they did attract a growing number of passengers. Londoners were apparently less bothered by tunnels supposedly filled "with smoke and noxious gases" than American capitalists of a later time liked to think. Passenger traffic did not fall off when dividends did. Though surface horsecar companies,

because of their small initial capital expense and a reduction in the price of horsefeed, showed a better profit than either underground line after 1875, the railways' traffic grew far more rapidly.¹¹ The negative precedent was of course the Metropolitan District, with its high initial cost and low earnings. But the circumstances of its construction and operation were peculiar to it. Its difficulties need not have deterred the New York capitalist, but rather might have served him as an object lesson in what to avoid in launching his own venture.

In the years after New Yorkers had decided against a subway, and when the elevated roads were already built, it was commonly held that London's experience had demonstrated that underground railroads were not attractive to patrons because of their smoky and dank tunnels, and that such roads could not conceivably be financially successful. But this view was a myth propagated by American capitalists. Russell Sage, part owner of the Manhattan Elevated Company, had reasons of his own for believing that "the traveling public would rather ride in the open than in a tunnel thirty feet underground."¹² And men like William Barclay Parsons and August Belmont, who in the 1890's voiced negative opinions on the technical feasibility and financial profitability of a steampowered underground railway in New York after the Civil War, were doubtless expressing what was by then the conventional capitalist wisdom.¹³

The question, then, gets down to this: was a subway like London's feasible or possible in New York in the late 1860's or early 1870's, before the decision was made to build elevated railroads, and before capital had invested large sums in one form of rapid transit, thereby precluding similar investment in another form. The answer, of course, is that subways were feasible but not possible, a fact that should become apparent once certain features of New York's business and political life are clearly understood.

Too much attention and far too much weight has been accorded the subject of motive power. Since a steam-driven subway was never built in New York, it is not possible to know whether New Yorkers would have adjusted, as Londoners did, to the smoke from locomotives and the smell of the tunnels. A New York subway would presumably have followed London's example in providing an abundance of ventilation shafts, and in using locomotives that burned coke rather than coal, and were equipped with steam-condensing engines, both of which cut down on the amount of smoke or exhaust gas discharged into the tunnel. New York needed a "truck line" underneath a principal street running through the center of town, as opposed to London's circular belt route with many open cuts and short tunnels, and this would have required at least one very long and possibly one or two nearly as long tunnels, which signified a ventilation problem much greater than London's. At the same time, with a well-worked out system of ventilation shafts, and four tracks with express service, the very speed of the express trains might have generated sufficient movement of the air to keep tunnels reasonably comfortable, or so at least several subway advocates claimed.¹⁴

The point here is not to argue that steam was an ideal motive power, but only to suggest that it did not, in and of itself, rule out the possibility of an underground railroad in New York in the late 1860's or early 1870's. It is an axiom of the history of capitalist society that technical innovation usually follows closely upon capitalist need or demand,¹⁵ which is enough to suggest that if capital had been willing, the necessary technology would have been forthcoming. And had there been nothing else to dissuade capital from such a venture, the matter of motive power would not have made much difference.

When compared to elevated railways, the cost of subways was an important but not decisive consideration arguing against underground railway construction. The American Society of Civil Engineers Report of 1875, which, as will be seen, had good reason to cite a low estimated figure for the construction of elevated roads, concluded that double-tracked elevated lines would cost between \$700,000 and \$1,125,000 per mile.¹⁶ This was close to their actual cost, at least as indicated in a report prepared in 1880 by Elnathan Sweet, an engineer, for the Railroad Committee of New York State Assembly, in which the capital outlay of the New York Elevated Company road, by that time virtually complete, was said to be \$8.7 million, and that of the Metropolitan Elevated line \$9.6 million.¹⁷ In testimony before the same Committee, Jose Navarro, one of the promoters of the Gilbert road, which later became the Metropolitan, claimed that his elevated road had cost approximately \$700,000 to \$800,000 per mile of double-tracked structure.¹⁸ These figures may be a little high, because W. F. Reeves, the most recent historian of the elevated roads in New York, cites the sum of \$2,525,240 for the Metropolitan Elevated Company's double-tracked road from Morris Street to 83rd Street, a distance of 6.12 miles, or a little more than \$400,000 per mile.¹⁹

Estimates for a subway ran considerably higher than any of the above figures for the elevated roads. In an 1865 brochure prepared as a promotion for the underground Metropolitan Railway, A. P. Robinson, the engineer of the proposed subway, estimated that the entire cost -- including equipment and cars, not counted in the above figures for the "els" -- of the railroad's approximately five-mile route from the Battery to 59th Street, would be \$8,487,006, or almost \$1.7 million a mile.²⁰ In 1875 the ASCE report concluded that a subway would cost \$2 million a mile to build.²¹ And in 1877, Alan Campbell, Commissioner of Public Works in Mayor Ely's administration, sent the Mayor a report recommending the construction of a subway, in which he cited figures from the proposed but never-constructed Vanderbilt plan for an underground line. The estimated cost for a five mile route -- again, with all equipment and rolling stock included -- was \$9.1 million, or roughly \$1.8 million a mile.²² Campbell also asserted that such a road could be profitable, that it might earn upwards of \$600,000 per year, and pay a yearly dividend of from six to seven percent.²³

Given the greater cost of an underground railway compared with that of an elevated road, it can be said that two conditions had to be met before a subway could be constructed. The first condition was substantial and reputable financial backing. A subway was beyond the means and the capacities of the small entrepreneur or even a group of small entrepreneurs. It was a risky project for all but the biggest capitalists, a man or a group of men who could afford the large initial expense of construction and equipment, and who could manage the road despite the likelihood of small returns in the first few years of operation.

Such men existed in New York and elsewhere in the United States after 1865, but the particular character of American economic development at this time worked against investment in subways or, for that matter, in intraurban transit of any kind. Money could and was being made in urban public transit, but it is significant that until the late 1870's and early 1880's, there was very little of what may be described as "big money" invested in urban mass transportation. The streetcar companies were small, numerous, and disorganized. Surface railway consolidation in Boston, Philadelphia, and New York had not yet begun. "Big money" interested in railroads invested in inter-urban rather than intra-urban transportation. The era following the Civil War was the great age of inter-urban railroad construction in the United States, and this took precedence over urban transit development.²⁴

In other words, the view that a subway "wouldn't pay" was in reality a relative rather than an absolute judgment. Given its cost and the risk involved, capitalists in position to build a subway could find much better ways to employ their money. The problem was that in the absence of positive governmental action and public funds for rapid transit construction, mass transportation in New York and elsewhere depended on capitalist initiative. And capitalists, at least in the period of inter-urban railroad development directly after the Civil War, regarded urban public transit as a distinctly second-class investment.

In the early 1870's, for example, Cornelius Vanderbilt was apparently interested in rapid transit, but only insofar as it related to the inter-urban railroad empire of the New York Central. With \$3.2 million or half the construction costs supplied by city funds, he did in fact build what Mayor Wickham described as a rapid transit road²⁵ -- his Hudson River "improvement" for the New York Central, which was a mostly open-cut or viaduct railway with short tunnels, running from 4th Avenue above 42nd Street to the Harlem River. In 1872 Vanderbilt also obtained a charter for a subway, the New York City Rapid Transit Railway, which was to run from City Hall Park to "a point between 48th Street and 59th Street." But there is good reason to believe that his purpose in securing this charter had very little to do with any desire to construct a subway. The route of his proposed underground line paralleled the one approved for the New York City Central Underground Railway. Vanderbilt's only aim in applying for this charter was to prevent the construction of the Central Underground, which if built would have served as an inner-city connection for inter-urban railroads that were rivals of the New York Central.²⁶

The second condition necessary for subway construction was that the road be located on a route which would insure a high return. In other words, a route that would exploit heavy downtown traffic in order to balance anticipated losses in the relatively undeveloped uptown parts of the city, until such time, of course, that the subway generate uptown settlement and created its own traffic. In 1865 Henry Varnum Poor, the railroad developer,²⁷ and his associates, John Jacob Astor and Abiel Low, were willing and able to build an underground railway, but their decision depended on the possibility of securing a proper route. In the 1890's, when the Rapid Transit Commission was planning New York's first subway, there were two such routes in lower Manhattan -- Broadway, and the newly improved Elm Street (now Lafayette Street). In the 1860's, however, only Broadway would have sufficed, and the problem was that Broadway, both then and later, was simply unavailable.

The entire problem of Broadway, and the source of the problem, the rights of Broadway property owners, can only be properly understood in relation to a larger context, which is that of the laws and legal procedures affecting urban railroads in the nineteenth century. In both England and America, the rights of private property owners were of course greatly respected, not only because property in itself was considered essential to the definition of human personality, but also because the defense of property rights served a public function. Those seeking to build a railroad in a nineteenth-century city such as New York or London, represented private interests asking for a considerable public privilege. They asked for the right to construct and operate their railroad through, on, under, or over private property on the public way, and the right in certain cases, to demand, condemn, or buy property that stood in the way of their "improvement." For this reason government everywhere regulated railroads, required them to be licensed or chartered, and, not unjustly, demanded that they prove that the communal need for their "improvement" was equal in value to the direct and indirect "social costs" it might incur. Another way of acquiring this "proof," and one that was particularly appropriate to the Anglo-Saxon legal system, was to pit private interests against private interests, so as to oblige the prospective railway builder to prove in a court of law that his railroad was undeniably a public necessity, worth the sacrifice of individual convenience or property. Only thus could the rights of one private interest be considered superior to those of another, and only thus could the public interest be clearly established.²⁸

In New York this whole question was even more complex, because all matters pertaining to the chartering and regulation of railroads were not, throughout most of the latter half of the nineteenth century, decided upon in New York City by New Yorkers, but in the state legislature at Albany by representatives from largely rural districts. New York City lacked real autonomy or self-government -- home rule -- and more than once in its history rural state legislators, usually Republican when New York was usually Democratic, and usually unconcerned with the city's real needs or desires, had given franchises to street railway operators whose credentials or the routes of whose railroads greatly displeased the citizens of

the city. By opposing the proposed construction of state-chartered railroads, and by bringing the matter before the courts, then, property owners such as those on Broadway were perceived not only as defending their own rights, but also as striking a blow for home rule.²⁹

In principle this concern shown by Broadway property owners for the public interest was of course commendable; in practice it was often abused. Throughout most of the nineteenth century, and certainly in the late 1860's and early 1870's, Broadway was the principal thoroughfare of New York City. It was the street with the most expensive real estate, both commercial property on lower Broadway below 14th Street, and, at least until the 1880's, residential property on upper Broadway above Union Square. Its landowners and merchants, among whom could be counted some of the richest and most powerful men in the city -- Astors, Goelets, the department-store mogul, A. T. Stewart -- ceaselessly stood watch over the rights and value attached to what was theirs. In effect, as was common in the nineteenth century, they exploited the general reverence for the rights of property and used their economic and political clout to preclude any "public improvement" on lower Broadway. Broadway property owners preferred to keep their street a high-class thoroughfare for carriages, omnibuses, and stagecoaches. They regarded any less swank form of transit as likely to downgrade the fashionable retail trade of their street, and railway construction of any kind as likely to cause inconvenience and damage, interfere with business, and possibly decrease the value of their property. It was only in the 1880's that they allowed a street railway to invade lower Broadway, and then only because, as the Record and Guide and numerous subway promoters noted,³⁰ real estate values below Union Square were declining, the fashionable retail trade was moving uptown, and the entire area was badly in need of the economic stimulation offered by public transit.

In the late 1860's and early 1870's, when the likelihood of a profitable route might have tipped the balance in favor of a subway, the opposition of property holders on lower Broadway constituted an insuperable obstacle to its construction. By the 1880's, however, when a new scheme for a Broadway subway -- the Arcade railway -- attracted considerable notice and some reputable backing,³¹ there was little possibility of a subway under Broadway or anywhere else. For by this time the "els" were already built, and their construction represented an investment in rapid transit of sufficient magnitude to deter further capitalist initiative for nearly two decades.

v

In the decade following the Civil War, New York required some form of rapid transit, and if subways were ruled out, then elevated trains were the next best and indeed the only alternative. But private capital's decisions not to build a subway did not imply a corresponding will on its part to construct an elevated railway system. Capital's reluctance to invest in public transit once again impeded and then determined the character of the rapid transit decision of the mid 1870's. Municipal government was mindful of the needs of the city and its citizens, but was limited in its vision and its actions by the need to stimulate capitalist initiative. Public construction of a rapid transit system was at the time considered neither desirable nor possible, and private construction depended on the guarantee of a low cost initial investment and immediate and substantial profit. Accordingly, city officials did their best to smooth the way for the realization of these last conditions, which resulted in an elevated railway system adequate to the needs of capital, but one which, within a very few years after its completion, was inadequate to meet the needs of the urban public it was supposed to serve.

The Senate Committee of 1866, it will be remembered, had recommended to the Legislature that Charles Harvey be allowed to construct a small section of his cable-powered elevated railway as an experiment. The Legislature approved this suggestion; the experimental half-mile segment was built on Greenwich Street from the Battery to Cortland Street; a subsequent Committee appointed by the Legislature approved further construction; and by 1870 Harvey's road was a single track cable-powered line running from the Battery to 30th Street. The Cable-powered road, however, was never popular, there were some accidents, and in 1871 the original company, the Westside and Yonkers Patent Railway, went bankrupt and was dissolved. The new company which was formed, the New York Elevated Railroad, requested the right to convert the road to steam power.¹ The progress of this company, in turn, was stalled by the panic of 1873. The same fate also befell a second elevated road, Rufus Gilbert's Elevated Company, chartered in 1872, which was to run along 6th Avenue to 59th Street on compressed air power.²

The ostensible failure of these two lines; the depression, the opposition of property owners, the incessant lobbying in Albany of streetcar companies who feared competition from rapid transit, and New York's great and immediate need for some kind of rapid transit, spurred several prominent New Yorkers and interested groups like real estate brokers to consider another alternative to private capital -- municipal construction. To men like iron-master Abram Hewitt, social reformer Simeon Church, and former Mayor Opdyke, all of whom spoke before a meeting of the newly formed Rapid Transit Association in February, 1873, it seemed as if the City would have to step in and lend a hand or face the fact that New York would never have rapid transit. Accordingly, they prepared a bill for the Legislature, sponsored by Mayor Opdyke, which called for the creation of a rapid transit commission with authority to select routes and devise plans for a four track rapid transit road.³

These men were aware that there was ample precedent for such positive governmental action. In New York itself and in America generally, there was the experience of building the Erie Canal and the canals in other states inspired by its example.⁴ In London there was the Metropolitan Railway, which owed its existence to an Act of Parliament and to the Corporation of the City of London, which had subscribed for half of its shares. In Paris in the 1850's and 1860's the Prefect of Police and the General Counsel of the Seine had organized all the omnibus lines into one company, the General Omnibus Company, had asserted their authority to lay down routes and timetables, even when these caused the Company to lose money, and had also created a consolidated street railway network for both Paris and its suburbs.⁵ Again, in New York itself there was an even more recent precedent than the Erie Canal: the agreement between Commodore Vanderbilt and City by which each would pay half the cost of his New York Central "Improvement."

Despite these precedents, however, municipal construction of rapid transit or the pledge of city funds or credit to a private firm for the same purpose, was not in the cards for New York in the 1870's. The city gift of \$3.2 million dollars to Cornelius Vanderbilt was a special matter, the exception that proved the rule. He owned the property and was also a man who could be trusted to improve it to everyone's satisfaction.⁶ The European precedents would someday exert an influence, but it was too soon as yet for New Yorkers to accept the European principle of "municipal socialism."⁷ The Erie Canal was a precedent too far off in the past; New York had changed a great deal since 1817. In the early 1870's the remembrance of the notorious Tweed gang, which had only been thrown out of office a few years before, and the possibility that Tammany might soon recapture City Hall, was sufficient to convince many citizens that the notion of municipal construction was, if not laughable, at least naive. Nor were Republican rural legislators in Albany likely to look with favor on the plunder that might potentially fall into the hands of their Democratic or Tammany rivals, should the City own and operate rapid transit lines.

In addition, there was considerable ambivalence, even among those most eager for rapid transit, to the principle of municipal construction. In 1871 Simeon Church managed to convince a meeting of the West Side Association, a group of realtors and property owners who looked to rapid transit for the development of their section of the city, to vote for a resolution in favor of municipal construction. But the same group rescinded this resolution at their next week's meeting.⁸ At another meeting of property owners in 1873, a resolution was passed which called for public construction, but in terms which make clear that this alternative represented a bitter pill, and one to which most New York businessmen, themselves understandably partial to private enterprise, resorted only out of desperation.

Resolved: That having heard explained several schemes for rapid transit in New York as private enterprises, this meeting expresses the hope that the Legislature will pass all the bills having that object in view which promise any success; but having no confidence whatever in the success of any private scheme, and no hope that rapid transit will ever be secured by private means, we earnestly urge upon the Legislature to pass the bill for the construction of a road as a City work as the only safe, sure, and economical measure of relief.⁹

With such feeble support behind it, with many who desired rapid transit nevertheless unwilling to make use of public funds, and with powerful interests opposed to it, the Opdyke bill, as might be expected, failed in the Legislature. Its failure, however, was not without significance for the future: later proposals for public support of rapid transit would take great care to separate the issue of municipal ownership from that of construction and operation.¹⁰

Once the use of municipal funds had been ruled out, subsequent developments appear to have followed a prepared script. It was decided not to initiate new rapid transit enterprises, but rather to encourage and smooth the way for those that already existed. This shut the door definitively on subway construction, and also signified that the city and its citizens would accept whatever the existing elevated lines -- the New York and Gilbert companies -- were willing to provide. In effect, it was no decision at all, but an acquiescence in a decision that had already been made by private capital, and which government, spurred on by now unified public support, real estate interests,¹¹ prominent businessmen, and, most important of all, the principal stockholders in the two elevated companies,¹² now hurried to confirm and further.

The first step in this process was the 1874-5 Report of the American Society of Civil Engineers, whose expert conclusions cannot be understood apart from the above context. The aim of this blue-ribbon panel of engineers¹³ was to unite public support behind the established private agencies of rapid transit construction. Their report stated that the major problem of the past had been that "lawmakers have been unwilling to grant charters until they knew on what plans the roads were to be built, and capital has refused to make in advance the necessary surveys and investigations, upon which alone adequate plans could be based."¹⁴ This was a problem effortlessly obviated, of course, by the existence of two already franchised elevated companies, one partially built along 9th Avenue, and the other with full-scale plans for a road on 6th Avenue. The ASCE report also suggested, rather redundantly, that franchises be given to companies "who now control the existing lines of transportation in the territory."¹⁵ and that further and more strenuous effort be made to secure rapid transit by private means before recourse to public construction was attempted. After having considered

seventy-five projects for different types of rapid transit construction, they arrived at several expert judgments on the relative merits of elevated as opposed to underground rapid transit, all of which come as no surprise. They concluded that elevated railroads would be less expensive to build than subways, that the latter would take longer time in construction than the former, and that underground roads, besides resulting in unhealthy and smoke-ridden tunnels, would also disturb sewerage, water, and gas pipes, as well as business and street traffic.¹⁶

The way thus paved by scientific expertise, Mayor Wickham took the next step. In a special message to the Board of Aldermen on 28 January 1875, he called for the establishment of a committee from among the aldermen to consider the rapid transit situation, noting that "it may . . . be now safely assumed that the discussions of the subject have produced a concurrence of opinions on these cardinal points," one of which was "that the work should be constructed, if practicable, by private capital, and not by the city," and "that capitalists should be encouraged to undertake the enterprise by permission to select routes along which business is likely to be profitable."¹⁷ In accordance with the Mayor's recommendations, a special committee of the Aldermen met to draft a bill to be sent to Albany. The majority of the committee first decided for construction by private capital, but with resort to public ownership within six months if this proved impractical. A few weeks later, however, "after more maturely considering the subject," they reversed themselves and took the view "that private enterprise should be granted a longer time in which to decide whether to undertake the enterprise, and that the proposed bill be so amended as to omit all provisions providing for an alternative public construction and operation."¹⁸ Nine of the aldermen resolutely held fast to the notion of municipal construction, but they were voted down by twelve others, and the bill went to Albany without a trace of this principle intact.

This bill, known as the Husted Act, was signed by Governor Tilden on June 19, 1875. It authorized the Mayor to appoint a five-man Rapid Transit Commission (RTC) with the power to lay down rules and conceive plans for rapid transit construction and operation. The Commission was accorded the power to create, if it so desired, new private corporations and to supervise both their organization and their subsequent construction of rapid transit roads. Provision was also made for the RTC to recognize the existence and supervise extension of the lines of the established elevated companies. If it selected routes which were identical to those held by existing lines, it could incorporate these lines anew as companies specially formed under the Husted Act. Both of these last two provisions, as will be seen, had a remarkable effect on the fortunes of the two established elevated roads.

Mayor Wickham's choice of commissioners was indicative of the close rapport existing between government and business in the late nineteenth century. He chose five prominent businessmen¹⁹ for the RTC, all of whom were involved in either the financial or manufacturing end of the iron and

railroad industries, and who thus had more than a passing knowledge as well as more than a passing interest in elevated railroad construction. They promptly set to work in order to accomplish the task for which they had been selected. Though presented with more than forty plans for various types of railroads, they quickly chose elevated steam roads as the "most practicable" form of rapid transit: ". . . considering the circumstances of the present situation,²⁰ and advised by engineers, and by capitalists as well -- we . . . reached the conclusion that elevated steam railways to be actually constructed in this city, but are the best for the purpose in view."²¹ The purpose in view also determined the routes they picked, which corresponded to the routes on 6th and 9th Avenues previously accorded the New York and Gilbert Elevated Companies. The old charters of these firms were thereby reconfirmed by the RTC²², which also gave them permission to construct and expand their lines on the West Side, and to build new lines on the East Side along 2nd and 3rd Avenues, all of which were to extend to the Harlem River.²³ In the event that these two companies failed to build or did not build their roads according to schedule, the RTC, availing itself of the provisions of the Husted Act, also formed a new corporation, the Manhattan Elevated Company, organized with an initial capital stock of \$2 million, which, by happy coincidence, was quickly subscribed for in equal parts by the major shareholders of the two railroads with prior franchises.²⁴

There can be no doubt that the Rapid Transit Commission of 1875 splendidly executed its mandate, which was in reality to foster and confirm the routes and plans already decided upon by private enterprise. That there was never any question of it doing anything else, is demonstrated, first, by the fare structure -- ten cents below, fifteen or more cents above 59th Street -- that it set up, and which, while doubtless helpful to capital, precluded working class travel on the elevated roads; and second, by the fact that the new corporation it established, the Manhattan Company, was formed wholly as a paper company, and had no property, built no roads, and was intended merely as a holding company for the existing lines constructed by the two other companies.²⁴

One would hardly describe the activity of the RTC of 1875, then, as having promoted a positive role for government in urban mass transportation; indeed, it did exactly the reverse, confirming, at least until 1894, the customary dependence upon private enterprise for public transit. At the same time, the Commission did exactly what it set out to do, which was to select the cheapest, most easily built, most available, least bothersome, and most technologically feasible form of rapid transit, and by governmental action to stimulate private capital to provide such a system for the citizens of New York.

And stimulate private capital it surely did. In the early days of elevated roads, before the Commission met, investors were few and capital insufficient. After 1875 the elevated roads attracted a whole new breed of capitalist: men like Jose Navarro, who actually built the Gilbert road through the medium of his New York Loan and Improvement Company; Cyrus Field,

the man responsible for the Atlantic cable, who took over the New York Elevated road in 1877; and, finally, two of the very greatest of the "robber barons," Jay Gould and Russell Sage, whose manipulations of the stock and fortunes of the Manhattan Company comprise too lengthy and complicated a story to tell here,²⁵ but who, by 1884,²⁶ had established monopolistic control over the only form of rapid transit existing in the world's second largest city.

vi

One need not search long or hard to discover what aroused Jay Gould and Russell Sage's interest in the elevated roads in the early 1880's. Nor is there any mystery surrounding the entrance in the mid '80's into the street railway business of such men as William C. Whitney and Thomas Fortune Ryan. From a city with a population of a little more than a million persons in 1875, New York, not counting its suburbs in Brooklyn and Long Island, had grown by 1890 into a city of nearly a million and a half. A city of such size, with so dynamic an economy, made ample use of the public transit that it had, or, in the near future, was likely to get.

In 1876, one year after the RTC's decisions, the total passenger traffic of all surface and elevated railways in New York was 167 million, and would grow even larger -- to 408 million -- by 1890. In 1876 the "els," only partially completed, had served but two million passengers; in 1886, with four roads complete to the Harlem River, they served 115 million passengers. And the street railways, profiting from the short-distance traffic of the "els", were in similarly healthy shape: in 1886 they carried 210.5 million passengers.¹

Public transit, in other words, could rely on ever-increasing market for its services, and, properly managed, could be made to "pay," and handsomely at that. Even so eminent a figure in the financial world as J. P. Morgan did not hesitate, in 1891, to join the board of Gould and Sage's Manhattan Elevated Company, which as Morgan noted, had gained respectability in the business world by virtue of its achieving a six percent annual dividend, then considered mandatory for a "paying" concern.² But the very reason -- money -- which had led men like Gould, Sage, Whitney, and Ryan to seek and eventually obtain control of the mass transportation facilities of New York, also determined their resistance to any improvement in that system, and represented, therefore, a major obstacle to the construction of another and more innovative mode of public transportation that New York badly needed -- a rapid transit underground railroad.

There were several reasons why the existing modes of public transit and the men who controlled them stood in the way of the building of a subway. To begin with, the management of the elevated roads and the surface railways feared competition from a subway, which, if it were correctly routed and had both local and express tracks, might detract both from the long haul traffic of the "els" and the short distance traffic of the streetcars. The elevated roads, moreover, did not want competition because they neither desired nor, as will be seen, could afford to meet this threat by expansion or improvement of their lines. They preferred to stand still, to make a large profit on their existing roads by running them badly and at minimal expense.

The surface railway monopoly cannot be accused of the same tactics. Indeed Whitney, Ryan and their Philadelphia mentors -- Peter A. B. Widener, William Kemble, and William Elkins -- who provided financial support and surface traction know-how, had invested vast sums in transforming a hodge-podge of competing horsecar lines into a consolidated system of cable-powered and, by the late 1890's, electrified street trolleys. Having devoted so much time, energy, and money to this effort, they were ready, at approximately the same time as New Yorkers began seriously to consider the construction of a subway, to cease the expansion of their own business, and to sit back contentedly and enjoy the fruits of their labor. The manner in which their own business had developed should have and perhaps did suggest to them that they be the ones to build a subway; along with their neatly organized system of consolidated lines and free transfers, a subway would have been all they needed to create a unified system with virtually monopolistic power over New York's public transit. But this, aside from the fact that they both wanted and needed time to accumulate profit before risking further expansion, would have brought them into overt competition with the management of the elevated roads, which from the very beginning of their business enterprise they had quite self-consciously chosen to avoid.³ And they had another reason, as well, for hesitating to undertake a subway venture. Their company, like the elevated company, could not afford it.

From its inception, even before Jay Gould and Russell Sage took control of it, the Manhattan Elevated Company was an enterprise built on "watered" stock -- that is, capitalization on the basis of anticipated earnings rather than actual assets. Its initial capitalization of \$2 million in 1875 was all water, since the company at that time existed only on paper, owned no property, and was not engaged in building any elevated roads; the \$2 million represented what it might become in the event that the two other roads -- the New York and Metropolitan companies -- failed to build. By 1879, when the Manhattan, because of quarrels over routing,⁴ leased the other two roads, its capitalization had increased to \$13 million, again all water, but useful for several purposes: first, to pay the lessors a dividend of ten percent on their similarly watered stock; second, to pay the interest on the lessors' construction bonds; third, to provide for operating expenses unrelated to earning power; and fourth, and most important, divide a profit, how much is not known, among all those concerned. Including the capital stock of the two leased roads and their construction bonds, the Manhattan's capitalization in 1880, as state in Elnathan Sweet's report to the Railroad Committee of the State Assembly was \$43 million, of which about \$25 million was water.⁵ This large sum did not preclude the Manhattan from failing to meet its obligations to both its shareholders and the lessor roads in its early years of operation. Earnings in the early 1880's increased slowly, and Gould and Sage, in attempting to gain control of the elevated roads, used the technique of stock manipulation to realize their objective.⁶ By 1888 the Manhattan's

capitalization was \$51 million, \$26 million stock and \$25 million bonds, by 1894, \$66 million, or \$30 million stock and almost \$36 million in bonds, and by 1899, \$88 million, or \$48 million stock and \$40 million bonds, with a market value of approximately \$100 million.⁷

Given the considerable earning power of the company by the early 1890's -- it carried 221.5 million passengers in 1893⁸ -- a capitalization of such proportions should presumably have allowed the company sufficient reserve to pay a good dividend, meet all its obligations with respect to construction bonds, taxes, etc., while still improving and extending its lines. However, this presumption would fail to take into account the fact that the Manhattan was paying dividends on watered stock that had risen in value several times over what it was bought for, and that it was also obliged to dispense some \$13 million in property abutment and damage payments,⁹ with four hundred such suits still pending as late as 1898. The RTC of 1875 had smoothed the way for private capital in every respect but this one, and it cost the Manhattan dearly. The only way the company could maintain its customary dividend of six percent was to reduce operating costs to a minimum and refrain from any but the most necessary improvements or extensions of its lines.

This Jay Gould and his son George, who took over the company's management after his father's death in 1892, resolutely strove to do. But his policy had to backfire; minimal operating expense meant bad service, and bad service resulted in decreased passenger traffic. As the Times, no friend of the Gould's, was quick to note, "a great transportation company in a city where the growth of passenger transportation is at the rate of 20,000,000 per year, shows a dwindling business, which it is making no effort to increase."¹⁰ By 1896 the road was losing passenger trips at an average rate of 12 million a year, was only able to manage a four a four percent dividend, and was thus obliged to reduce service further yet: a vicious cycle. These figures help to explain why the Manhattan hesitated to change the motive power of its trains from steam to electricity, beginning this transformation only in 1899 and completing it in 1903, at least six years after the new technology had thoroughly proven its feasibility and economy.¹¹ They also explain why it was preposterous for anyone, least of all the Rapid Transit Commissions of 1891 and 1894, to assume that the Manhattan would agree to costly expansions of its lines or build additional tracks on all its lines for express trains. Such improvements would have required a nearly total reconstruction of the road -- new elevated structures, new trains, perhaps a whole new series of abutment suits as well -- and this the Manhattan simply could not afford.

Though the surface railway monopoly, the Metropolitan, was a very different kind of business enterprise than the Manhattan, it had financial problems of its own, most of which stemmed from its success. In contrast to the Manhattan, which did nothing to improve its system after it absorbed the Bronx elevated lines of the Suburban Rapid Transit Company in 1891,¹² the Metropolitan was an expanding, active business. In endeavoring to consolidate nearly seventy-five percent of the city's surface railways between 1886 and 1895, Whitney, Ryan, and their Philadelphia allies bought or leased a variety of companies. All of these had watered stock, so when bought they fetched high prices, and

when leased they demanded and received extravagant rentals in perpetuity, and large dividend payments for their shareholders. These companies were also bought or leased in a wholly unimproved and sometimes defunct condition, and all of them were horsecar lines, which obliged the syndicate to replace worn-out equipment, and, especially for the more important lines on principal thoroughfares, to switch from horse power to newer technologies -- first to cable power and then to electricity.

The result of all this activity was an almost entirely new, improved, well-managed,¹³ and highly functional surface railway system for the city of New York. The lines were rearranged so as to complement rather than to compete with each other; new equipment, larger cars, cable and electric traction, provided better service, more comfortable travel, and, as far as it was possible for surface railways, much faster transportation. Consolidation and, after the initial expense, the reduced costs of the new technologies, meant decreased operating expenses, a gain which was in turn passed on to the consumer in the form of lower fares and the institution of a transfer system. Passenger traffic increased steadily, attaining a total of 185 million in 1896.¹⁴ The Metropolitan was a huge success, what Whitney's reverent biographer describes as an "empire on wheels."¹⁵

An empire perhaps, but one that was very expensive to build and maintain. Widener, Elkins, and Kemble had a great deal of money from their older and already successful Philadelphia traction enterprise, but not enough to manage the financing of this sort of operation. The syndicate therefore paid for a substantial part of its purchases, leases, new equipment, and technological improvements with watered stock of its own. Writing in 1902, after the Metropolitan had absorbed its last competitor, the Third Avenue Railway, Milo Maltbie¹⁶ of the reform journal, Municipal Affairs, judged that the combined real property value of the now complete monopoly was \$60 million, but that the market value of its stock was \$221 million and its par value \$165 million -- in other words, \$105 million in water on the best estimate.¹⁷ In addition to the obvious problem of dividends paid out on heavily watered stock, there was also the burden of costs for leases, and the overestimation of assets without accounting for depreciation, a problem especially grievous for a firm that had inherited so much out-of-date equipment. Nor was this all: the system of free transfers, as useful as it was in attracting passengers, failed to work; with a five cents fare reduced to two and one-half cents because of the transfers, the company lost money.¹⁸ The empire, as even the same reverent biographer was forced to acknowledge was "top heavy and leaned upon too many weak reeds and poor earners to acquire added value simply because of being purchased or leased."¹⁹

As early as 1899, then, the year that the Metropolitan made a surprising offer to the Rapid Transit Commission to construct a subway, the syndicate was already in trouble. Whether the offer was genuine, or whether the Metropolitan merely made it to delay the Commission's work and forestall competition, is a question that will be discussed at length in the following

chapter. Here all that need be said is that the terms of the offer reflected a gross error of judgment with respect to public opinion, and this was a curious misperception for someone usually so astute as William C. Whitney.²⁰ And the fact of the matter was that even had these terms been accepted, the Metropolitan was too busy -- in 1899 it was battling to take over the Third Avenue Railway -- and too entangled in a financial web of its own devising, to undertake such a large and innovative venture as subway construction.

But if the Metropolitan could not or would not build a subway, and if the Manhattan were similarly unwilling or incapable of substantially improving the one existing mode of rapid transit, who then would or could? Here an earlier point may profitably be underscored: one key to understanding the entire story of the subway, from the early schemes of the 1860's to the beginning of actual construction in 1900, is to see that the man who might conceivably take on such an enterprise would have to be highly reputable and capable of drawing upon vast resources of capital. Given the public transit situation as it existed in the 1890's, such a man required another quality as well: he would have to be a railroad or traction magnate, someone with experience and expertise acquired in running, organizing, and fighting the financial wars involved in the creation of a large railroad or traction network. For even with the pledge of public funds for construction, the job was a big one and the subway, when built, had to be coordinated with other modes of public transit so as to be successfully and profitably run for fifty or seventy-five years under private management.

And here the two extant transit monopolies, by the very fact of their existence, were sufficient to discourage all but the most hardy -- or, as the case may be, foolhardy -- entrepreneur. These two heavily watered companies represented a very large capital investment in public transportation. Conservative businessmen doubtless recognized that if a subway were built by someone outside the sphere of the two existing transit monopolies, competition of a counter-productive sort might result. Despite the belief of later Progressive reformers in the benefits of competition, a competitive battle between three companies providing similar services was not regarded by most capitalists as likely to further the goal of an efficient and comprehensive system of public and rapid transit. Perhaps even more important, the financial stability of the public transit industry might suffer and large investments be endangered, should competition materially affect the market status of the two existing transit monopolies. This meant that any willing to build a subway would not only have to possess the skill and experience to deal with competition and opposition from the Manhattan and Metropolitan, but would also have to create a new monopoly, larger and more powerful than the first two, and capable of incorporating them within a newly organized and consolidated system of urban mass transportation.

Until New York's first subway was a fait accompli, this appeared to be and was in fact a formidable enterprise, one for which only a very few capitalists were eligible. By the early 1890's the inadequacy of the "els" and the surface

railways argued convincingly for a subway as the one remaining answer to New York's rapid transit problem. But the implementation of the rapid transit subway decision depended, as before, on capitalist initiative, which, because of the two existing transit monopolies, would remain a surprisingly scarce commodity in the largest and wealthiest city in the United States.

Part I, i

- ¹London's first subway, the Metropolitan Railway, opened from Paddington to Farringdon Street on January 10, 1863. The first phase of its construction, however, was not complete until December 23, 1865, when it was extended to Moorgate Street. See T.C. Barker and Michael Robbins, A History of London Transport:I (London: George Allen and Unwin, 1963), pp. 99-135.
- ²For a discussion of New York as a "walking city," with industry, retail and wholesale commerce, and residences huddled around its port, see G.R. Taylor, "Mass Transportation, Part I," pp. 38-40.; Joel Arthur Tarr, "From City to Suburb: The Moral Influence of Transportation Technology," in Alexander B. Callow, Jr., ed., American Urban History, Second Edition (New York: Oxford University Press, 1973), pp. 202-212. For a discussion of the relation between patterns of urban growth and the transition from commercial to industrial capitalism, see David Gordon, "Capitalism and the Roots of Urban Crisis," in Roger E. Alcala and David Mermelstein, eds., The Fiscal Crisis of American Cities (New York: Vintage, 1977), pp. 82-112.; and David Ward, "The Emergence of Central Immigrant Ghettoes in American Cities, 1840-1920," Annals of the American Association of Geographers, LVIII (June 1968), 343-351.
- ³G.R. Taylor, "Mass Transportation, Part I," pp. 38-48.; Robert Ernst, Immigrant Life in New York City 1825-1863 (New York: King's Crown Press, 1948), pp. 48-60. The symbiotic relation of slum and suburb in the development of cities like New York and London is discussed in H.J. Oyos and D.A. Reeder, "Slums and Suburbs," in The Victorian City, I, 359-386. Simply put, the argument is that as suburbs developed, both capital and middle classes withdrew from certain districts of the city, thus producing slum housing for the poor and working classes. The rise of slums adjacent to the central business district of nineteenth-century cities is also explained by the fact that land potentially reserved for high density and more profitable development as industrial or retail quarters is rented, until the market for such development matures, at exorbitant rates to the working classes, who need to be within easy distance of their employment. The rich leave the area adjacent to the central business district; the poor stay until they are pushed out by one form or another of "urban renewal" which serves to expand the central business district. In this regard, see David Harvey, Social Justice and the City (Baltimore, Maryland: The Johns Hopkins University Press, 1973), pp. 153-194.; Gordon, "Capitalism," pp. 98-100.; Friedrich Engels, "The Housing Question," in Karl Marx-Friedrich Engels, Selected Works, 2 vols. (Moscow: Foreign Language Publishing House, 1953), I, 557-635.

Part I, ii

- ¹New York State, Report of the Public Service Commission for the First District of New York for the Six Months ending December 31, 1907 (Albany, New York, 1908), I, 454-455 (Hereafter cited as Report of the P.S.C. 1907).

² Charles Windsor Cheape III, "The Evolution of Urban Public Transit 1880-1912: A Study of Three Cities" (Ph.D. diss., Brandeis University, 1976), pp. 1-26.; Sam Bass Warner, Jr., Streetcar Suburbs: The Process of Growth in Boston 1870-1900 (New York: Atheneum, 1975), pp. 20-29.; Glen E. Holt, "The Changing Perception of Urban Pathology: An Essay on the Development of Mass Transit in the United States," in Kenneth Jackson and Stanley K. Schultz, eds., Cities in American History (New York: Alfred Knopf, 1972), pp. 324-343.

³ Walker, Fifty Years, pp. 59-61.; Report of the P.S.C. 1907, I, 454.

⁴ Report of the P.S.C. 1907, I, 455.

⁵ Ibid.

⁶ Ibid.

⁷ Ibid.

⁸ John R. Kellest, The Impact of Railways on Victorian Cities (London: Routledge and Kegan Paul, 1969), pp. 50-57.

⁹ Walker, Fifty Years, p. 68.

¹⁰ Report of the P.S.C. 1907, I, 455.

¹¹ Ibid.

Part I, iii

¹ "A History of Real Estate, Building, and Architecture in New York City 1868-1893," Real Estate Record and Builder's Guide, LIII, Supplement (June 1894), 1-143. (The journal is hereafter cited as Record and Guide; the Supplement as "History of Real Estate").

² "History of Real Estate," p. 19.

³ Ibid., p. 22.

⁴ Ibid., p. 30.

⁵ In 1870, when the population of New York was 942,292, 497,289 persons resided in the area below 14th Street; in 1880, with a New York population of 1,206,299, 542,251 persons resided in the same area. On the problem of density below 14th Street, see Seymour Mandelbaum, Boss Tweed's New York (New York: John Wiley and Sons, 1965), p. 12.; Rischin, The Promised City, pp. 76-94.; Lubove, Progressives and Slums, pp. 25-48.; George Rogers Taylor, "The Beginnings of Mass Transportation in Urban America, Part II," The Smithsonian Journal of History, I, 3 (Autumn 1966), 52.; Robert Clarkson Brooks, "History of the Street and Rapid Transit Railways of New York City" (Ph.D. diss., Cornell University, 1903), pp. 132-134.; and, especially, John Isaacs Davenport Letter of John I. Davenport, Esq., on the subject of the population of the City of New York, its density and the evils resulting therefrom (New York: The Arcade Railway, 1884), p. 4. On the development of

New York above 14th Street in the period 1868-1893, see "History of Real Estate," pp. 46-143.

⁶ "History of Real Estate," pp. 46-143.

⁷ Steen Muller Rasmussen, London: The Unique City (London: Macmillan, 1937).; Donald J. Olsen, Town Planning in London: the Eighteenth and Nineteenth Centuries (New Haven, Connecticut: Yale University Press, 1964).; D.A. Reeder, "A Theatre of Suburbs: Some Patterns of Development in West London, 1801-1911," in H.J. Dyos, ed., The Study of Urban History (London: Edward Arnold, 1968), pp. 253-271.; Lynn Lees, "Metropolitan Types: London and Paris Compared," The Victorian City, I, 413-428.

⁸ Lees, "Metropolitan Types," I, 417.; David H. Pinkney, Napoleon III and the Rebuilding of Paris (Princeton, New Jersey: Princeton University Press, 1972), pp. 3-24.; Anthony Sutcliffe, The Autumn of Central Paris: The Defeat of Town Planning 1850-1970 (Montreal: McGill-Queen's University Press, 1971), pp. 4-5. Paris remained surrounded by the octroi wall of Louis XVI until 1861 and by the fortifications of Louis Philippe until the First World War. As the result of being confined within walls, Paris achieved a very high level of population density, and developed what came to be known as the "French flat" or apartment house.

⁹ Walker, Fifty Years, p. 1.; Davenport, Letter, p. 3.; G.R. Taylor, "Mass Transportation, Part I," p. 37.

¹⁰ G.R. Taylor, "Mass Transportation, Part I," pp. 38-40. The Record and Guide points out, however, that if this new pattern somewhat predated the Civil War, it was in no way apparent before 1850. See "History of Real Estate," p. 22.

¹¹ Record and Guide, XIX (May 19, 1877), 396.

¹² New York City, Communication from His Honor the Mayor (Smith Ely) to the Board of Aldermen, Transmitting the Report of Alan Campbell Esq., Commissioner of Public Works, on the Subject of Rapid Transit (New York, 1877), p. 22 (Hereafter cited as Campbell, Report on Rapid Transit).

¹³ As quoted in Walker, Fifty Years, pp. 61-62.

¹⁴ New York Times, November 23, 1873

¹⁵ Record and Guide, XVI (December 11, 1875), 790.

¹⁶ Record and Guide, XIX (May 19, 1877), 396.

¹⁷ Ibid.

¹⁸ Record and Guide, XX (September 22, 1877), 729-30.; Record and Guide, XXIII (May 3, 1879), 349.

¹⁹ Record and Guide, L (July 16, 1892), 72.; LI (January 21, 1893), 82.; LII (October 21, 1893), 465-66.; LIV (July 7, 1894), 2-4.; LV (February 9, 1895), 204-05.

- ²⁰ Record and Guide, XIX (May 19, 1877), 395. "It is no rash speculation or wild conjecture which move us to predict that, in the distant future, probably within the present century of our national existence, this metropolitan district may be brought within the jurisdiction of a single government, and that business occupations and domiciliary enjoyment will be exercised under the operation and protection of one code of laws." For further information regarding the role of the Record and Guide in the movement for the consolidation of Greater New York, see Hammack, "Participation in Major Decisions," pp. 113-312.
- ²¹ In 1880 New York was recognized by the United States Census as the nation's first metropolitan area. See U.S. Bureau of the Census, Tenth Census of the United States 1880: Report on Social Statistics of Cities (Washington, D.C.: Government Printing Office, 1886), I, 531-532. (Hereafter cited as Report on Social Statistics 1880).
- ²² Bahret, "New York's Growth," pp. 408-09.
- ²³ Ibid.
- ²⁴ Henry C. Gardiner, An Address, entitled Rapid Transit, or the loss in population and value of real estate in New York City and Westchester County arising from the want of accommodation for trade and travel between the limits of Manhattan Island, delivered before a meeting of the owners of real estate in New York City and Westchester County (New York, 1970), pp. 1-3.
- ²⁵ Ibid., p. 1
- ²⁶ Between 1860-1870 New York's population grew from 813,669 to 942,292, or an average annual rate of increase of 1.5%. Brooklyn's population grew from 266,661 to 396,099 in the same period, or an average annual increase rate of 4.85%. Jersey City experienced an 18.24% annual rate of increase, as its population grew from 29,226 to 82,546. Hoboken's population increased from 9,662 to 20,297, or 11.01%, and Newark from 71,941 to 105,059, or 4.60%. See Report on Social Statistics, I, 471-698.; Rosenwaike, Population History, pp. 55-67.; Bahret, "New York's Growth," pp. 405-407.
- ²⁷ New York Times, December 26, 1874
- ²⁸ There were four elevated roads -- the Sixth Avenue, Ninth Avenue, Third Avenue, and Second Avenue -- in Manhattan, all completed by the early 1880's and run by the Manhattan Elevated Railroad Company, which, after 1884, was wholly controlled by Jay Gould and Russell Sage. It was only in 1886, however, that the elevated trains of the Suburban Transit Company began to operate in the Bronx. See William Fullerton Reeves, The First Elevated Railroads in Manhattan and the Bronx of the City of New York (New York: New York Historical Society, 1936).; and Julius Grodinsky, Jay Gould. His Business Career 1867-1892 (Philadelphia: University of Pennsylvania Press, 1957), pp. 288-315.
- ²⁹ See Rosenwaike, Population History, pp. 63-81. Between 1880 and 1890 alone, New York's immigrant population increased by 161,00, or, counting 133,000 foreign born immigrants who died in the same decade, a net immigration of 294,00.

- ³⁰ That the New York Sun was probably on the payroll of Jay Gould and his associates on the board of the Manhattan Company was hinted at during the period. See the New York Times, March 22, 1889.
- ³¹ Record and Guide, XXIII (February 8, 1879), 101.
- ³² Record and Guide, XXV (February 14, 1880), 147.
- ³³ "History of Real Estate," p. 45.
- ³⁴ New York Times, January 18, 1880
- ³⁵ See John Flavel Mines, Rapid Transit and its effect upon Broadway Real Estate (New York: Arcade Railway, 1884), pp. 1-13.; Campbell, Report on Rapid Transit, p. 16.; William J. McAlpine, The New York Arcade Railway as projected, compared with the underground railways of London (New York: Arcade Railway, 1884), p. 10.
- ³⁶ "History of Real Estate," p. 44.; Brooks, "History of Street and Rapid Transit Railways," pp. 165-166. In the first three years (1877-1880) after the elevated railroads began operation, traffic on the surface lines did fall off considerably, losing as much as 19,200,000 passenger trips between 1878 and 1879. But after 1880, when the "els" were virtually complete, they generated sufficient traffic for themselves and enough "spill over" traffic for the surface lines, so that by 1885 the latter carried 193,700,000 passengers, a gain of thirty million over 1877.
- ³⁷ See Tarr, "From City to Suburb," pp. 203-210.
- ³⁸ Weber, Growth of Cities, p. 474.
- ³⁹ Davenport, Letter, p. 17.
- ⁴⁰ Report of the P.S.C. 1907, I, 459.
- ⁴¹ "History of Real Estate," p. 44.
- ⁴² Weber, Growth of Cities, p. 413, n.3.
- ⁴³ G.R. Taylor, "Mass Transportation, Part II," p. 54, n.73.
- ⁴⁴ Davenport was a lawyer, journalist, political reformer, and public electoral expert who prepared A Directory of the Registered Voters of the City of New York (1877), and wrote a book on political corruption, The Election Frauds of New York City and Their Prevention (1881). He was responsible for drafting the first Federal Election Law, which Congress passed in 1870. President U.S. Grant appointed him Federal Elections Commissioner in the same year, and after Grant left office in 1876 he also served as Chief Supervisor of Elections in New York until he was replaced in 1893. He was prominently associated with the reform wing of the Republican party through membership in the Union League Club. See his obituary in the New York Times, August 28, 1903.

- ⁴⁵ See David Ward, "Central Immigrant Ghettoes," p. 346.
- ⁴⁶ Remarks of the celebrated American sociologist, Charles Horton Cooley, as quoted in Weber, Growth of Cities, p. 474. See also Tarr, "From City to Suburb," pp. 203-210.; and Weber, "Rapid Transit and the Housing Question," pp. 409-417.
- ⁴⁷ See Peter J. Schmitt, Back to Nature: The Arcadian Myth in Urban America (New York: Oxford University Press, 1969); Paul Boyer, Urban Masses and Moral Order in America 1820-1920 (Cambridge, Massachusetts: Harvard University Press, 1978), pp. 3-21, 123-294.; Tarr, "From City to Suburb," pp. 203-210.
- ⁴⁸ Davenport, Letter, p. 11.
- ⁴⁹ Ibid., p. 9.
- ⁵⁰ Ibid., p. 5. See also Lubove, Progressives and Slums, pp. 94-95., who cites the Tenement House Committee of 1894, which estimated the average population density of Manhattan below the Harlem River as 143.2 persons per acre.
- ⁵¹ Davenport, Letter, p. 7.; and Lubove, Progressives and Slums, pp. 258-259.
- ⁵² Davenport, Letter, p. 8.
- ⁵³ Ibid., p. 11.
- ⁵⁴ Ibid., p. 14.

Part I, iv

- ¹ New York State, Report of the Public Service Commission for the First District of the State of New York for the Year ending December 31, 1913 (Albany, New York, 1914), V, 20-25, 51, 68-69, 293, 312, 333, 690, 842, 898, 922, 935, 1005-1006, 1104, 1285, 1334, 1342. (Hereafter cited as Report of the P.S.C. 1913).
- ² Report of the P.S.C. 1913, V, 922.; and Brooks, "History of Street and Rapid Transit Railways," pp. 150-152.
- ³ Report of the P.S.C. 1913, V, 20-25, 68, 842.
- ⁴ Brooks, "History of Street and Rapid Transit Railways," p. 140.; New York Times, October 16, 1869 (for discussion of the fraud and speculation engaged in by Central Underground promoters). Arthur became president of the Arcade Railway in 1886, but the real power behind the projected railway was its chief promoter, Melville C. Smith.
- ⁵ As quoted in Barker and Robbins, London Transport I, p. 118.
- ⁶ Among these, the most prominent were Charles Pearson, the noted reformer, Chairman of the London Board of Health, Common Council

member, and London City Solicitor, and Sir John Fowler, the great public works engineer who built the Aswan Dam, the London and Brighton Railroad, and Forth Bridge. See Barker and Robbins, London Transport I, pp. 101-102n., and 105n.

⁷ Barker and Robbins, London Transport I, p. 113. The Corporation of The City of London subscribed to ~~£~~200,000 of the ~~£~~950,000 cost of the Metropolitan.

⁸ Ibid., pp. 134-135. In 1868 the Metropolitan registered 27,708,011 passenger trips, and netted a profit of ~~£~~150,271.

⁹ Ibid., p. 237.

¹⁰ Jack Simmons, "The Power of the Railway," Victorian Cities, I, 283.

¹¹ Simmons, "Power of the Railway," p.283.; Barker and Robbins, London Transport

¹² For Sage's remark, see New York Times, January 19, 1900. Of course Sage saw the construction of a subway as a threat to his own badly managed Manhattan Elevated Company.

¹³ Parsons described the Metropolitan and Metropolitan District railways as financially unsuccessful from the start, and unsuitable to passenger traffic because steam locomotives filled "the tunnel with smoke and noxious gases." See William Barclay Parsons, Rapid Transit in Great Cities. An Address Delivered before the Faculty and Students of Purdue University (Lafayette, Indiana: Purdue University, /February 24/ 1904), pp. 6-8. Parsons' description belies the first hand accounts of Metropolitan Railway passengers when it opened in 1863: "Mary Anne and I," Sir William Hardman recorded in his diary, "made our first trip down the 'Drain.' We walked to the Edgeware Road and took first class tickets for King's Cross (6d. each). We experienced no disagreeable odour, beyond the smell common to tunnels. The carriages (broad gauge) hold ten persons, with divided seats, and are lighted by gas (two lights); they are also so lofty that a six footer may stand erect with his hat on . . ." As quoted in Barker and Robbins, London Transport I, p. 117. Parsons' view also discounts the profitable showing of the Metropolitan in its first five years of operation.

August Belmont II, President of the IRT company, held that steam powered subways could not be profitable, whereas subways powered by electric traction "would pay." See Walker, Fifty Years, p. 168.

¹⁴ I.K. Brunel, engineer of the London Great Western Railroad, testified before a Parliamentary Committee in 1853 in favor of the (then) proposed Metropolitan Railway. His view was that "ventilation of the tunnels would pose no problem, because generally speaking, the passage of a train through a tunnel creates such a commotion and change of air that I do not know of any difficulty in any tunnel that I am acquainted with . . ." As quoted in Robbins, London Transport I, p. 109. A.P. Robinson, the engineer and designer of the proposed but never built Metropolitan underground railway in New York, argued in 1865 that the more difficult ventilation problem facing New York could be solved by means of pipes running laterally to convenient openings

and connected with hollow iron gas lamp posts about fifteen inches in diameter, erected on the surface of the street at the edge of the sidewalks. See A.P. Robinson, Report upon the contemplated Metropolitan Railroad of the City of New York (New York: Clayton and Wadole, 1865), p. 28.; Walker, Fifty Years, p. 22.; and McAlpine, The Arcade compared with the undergrounds of London.

- 15 This is the view which bears the authority of Paul Mantoux in his classic study, The Industrial Revolution in the Eighteenth Century (New York: Harper and Row, 1961), p. 206.
- 16 American Society of Civil Engineers, Rapid Transit and Terminal Facilities (New York, 1875), p. 31.
- 17 Elnathan Sweet, Supplemental Report Relating to the Elevated Railroads of the City of New York (Albany, 1880), pp. 9-41.
- 18 As cited in Walker, Fifty Years, p. 113.
- 19 Reeves, The First Elevated Railroads, p. 20.
- 20 Robinson, Metropolitan Railroad, pp. 22-24.
- 21 Campbell, Report on Rapid Transit, pp. 15-16.
- 22 Ibid.
- 23 Ibid.
- 24 In the two decades after the Civil War big capital concentrated on organizing and building the interurban railroad industry. It was only when the inter-urban railroad system had reached the point of "organic composition" -- that is, uniform and large fixed capital investment and highly organized monopolistic management -- that capitalist interests turned to mass transit. Management and financial techniques -- e.g., the holding company, the use of leases and the exchange of stock to purchase other lines while conserving capital, the staff divisional structure -- developed in the interurban railroad industry were then emulated by transit magnates like Henry and William C. Whitney, Thomas Fortune Ryan, Charles Yerkes, Peter Widener, William Kemole, William Elkins, and Anthony Brady. But these men, and the financial and management techniques with which they constructed their transit empires, did not come to the fore until the 1880's and 1890's, when new technologies -- cable power and electric traction -- required much larger amounts of capital investment and a more highly rationalized organization of the mass transit business. Until the 1880's, however, the transit industry remained a business controlled by a great number of small-time entrepreneurs. See Alfred D. Chandler, Jr., The Railroads: The Nation's First Big Business (New York: Alfred Knopf, 1965).; and Alfred D. Chandler, Jr., Strategy and Structure: Chapters in the History of the Industrial Enterprise (Cambridge, Massachusetts: Harvard University Press, 1962), Ch. I.; See also Cheape, "Evolution of Urban Public Transit," pp. 1-21.; Warner, Streetcar Suburbs, pp. 20-29.; Mark D. Hirsch, William C. Whitney, Modern Warwick (New York: Dodd, Mead, and Company, 1943), pp. 207-226, 421-468, 511-540.; Burton J. Hendrick, "Great American Fortunes and Their Making," McClure's Magazine, XXX

(November 1907- January 1908), 33-48, 236-245, 323-338.; Herbert H. Vreeland, "The Street Railways of America," in C.M. Depew, ed., One Hundred Years of American Commerce, 2 vols. (New York: D.O. Haynes and Company, 1894), I, 141-148.; Brooks, "History of Street and Rapid Transit Railways," Chs. I-IV, IX-XI.; Harry J. Carman, The Street Surface Railway Franchises of New York City (New York: King's Crown Press, 1919).

²⁵ Report of the P.S.C. 1907, I, 456.

²⁶ Brooks, "History of Street and Rapid Transit Railways," pp. 150-152.

²⁷ See Alfred D. Chandler, Jr., Henry Varnum Poor: Business Editor, Analyst, and Reformer (Cambridge, Massachusetts: Harvard University Press, 1956).; and Walker, Fifty Years, pp. 11-14.

²⁸ Kellett, Impact of Railways, pp. 25-33.

²⁹ Carman, Street Railway Franchises, pp. 85-86, 103, 108.

³⁰ McAlpine, The Arcade compared with the Undergrounds of London, p. 10.; Mines, Rapid Transit and Broadway Real Estate, pp. 1-15.

³¹ By 1888 several reputable businessmen were attracted to the Arcade project, including Frederick P. Olcott of the Central Trust Company (who, because of his association with the Arcade, failed to qualify as a member of the Rapid Transit Commission of 1891), Richard Elmer of the American Surety Company, Edward A. Abbott of Abbott, Downing, and Company, and General James Jourdan of Brooklyn, who would be involved with August Belmont in the New York District Railway scheme, in the Kings County Elevated Railroad, the Brooklyn Rapid Transit Company, and the IRT. See Record and Guide, XLI (June 2, 1888), 703.

Part I, v

¹ The Westside Patented Elevated Railway Company requested permission of the Transit Commission to use steam power. Permission was granted on February 9, 1871, and on April 20, 1871, steam-driven elevated trains began operation. In the summer of 1871 the Westside Patented Elevated went bankrupt, and the New York Elevated Company, with a capital stock of \$10 million was formed. The New York Elevated in turn requested the right to use steam-driven engines, which was granted on May 20, 1876. See Reeves, The First Elevated Railroads, pp. 8-13.

² The depression of 1873-1879 made it difficult for elevated road promoters to find capital. The Gilbert Company did not find sufficient capital until 1876, when an arrangement was made between it and the New York Loan and Improvement Company, in which José Navarro was a leading figure. Construction of the Gilbert road began subsequent to this arrangement. See Reeves, The First Elevated Railroads, pp. 16-20.

³ An Act to Create a Board of Commissioners of City Railways and to Provide Means of Rapid Transit in the City of New York (New York, 1873). Copy of proposed bill in New York Public Library. See also

Brooks,, "History of Street and Rapid Transit Railways," p. 154.

⁴See Rubin, "The Erie Canal," pp. 15-67.

⁵See Sutcliffe, Autumn of Central Paris, pp. 79-83.

⁶Walker, Fifty Years, p. 128., misunderstands the basic principle involved in what he calls "the outright gift of \$3,200,000 to a corporation for improving its own property," and which he sees as "a contradiction of the evidently prevalent opposition to public ownership. The point is that the patrician and business elite of the 1870's believed that capitalists like Vanderbilt could be trusted to use city funds wisely and well, whereas city officials were not similarly trustworthy.

⁷The term "municipal socialism" probably originated in England and has often been attributed to Sidney Webb of the Fabian Society. See A.M. McBriar, Fabian Socialism and English Politics 1884-1918 (Cambridge, England: Cambridge University Press, 1966), pp. 25-27, 107-109, 191-195, 296-298, 319-320. In America it was Albert Shaw, the editor of the reformist journal, The Review of Reviews, who popularized the term, while emptying it of any true socialist connotation. By "municipal socialism," Shaw meant the merely expedient use of public funds to provide necessary public services for all citizens. Shaw was not a socialist in the accepted sense of the word. For Shaw's numerous articles on the subject of municipal reform in Europe and America, see the extensive bibliography in Lloyd J. Graybar, Albert Shaw of the Review of Reviews: An Intellectual Biography (Lexington, Kentucky: University of Kentucky Press, 1974), pp. 206-220.; and Albert Shaw, Municipal Government in Great Britain (New York: Century Company, 1895) and Municipal Government in Continental Europe (New York: Century Company, 1895).

⁸West Side Association of the City of New York, Proceedings of Public Meetings, Document 3, 11-38.; Document 2, 56.

⁹New York Times, May 18, 1873.

¹⁰See below, Part II.

¹¹As has been already noted, the Record and Guide was an ardent advocate of rapid transit and, when no more suitable form seemed likely, a consistent friend of the elevated roads all through the period 1875-1894. See particularly Record and Guide, XXV (February 114, 1880) 147.

¹²See Walker, Fifty Years, p. 110. The investors in the New York Elevated and Metropolitan companies quickly and efficiently bought all the stock of the Manhattan Railroad, a paper holding company created in case either one or the other of the two companies failed to honor their commitment to build.

¹³The committee of the ASCE consisted of Octave Chanute, M.N. Formey, Ashbel Welch, Charles K. Graham, and Francis Collingwood.

¹⁴ASCE, Rapid Transit Facilities, p. 31.

¹⁵Ibid., p. 33.

¹⁶Ibid.

¹⁷Report of the P.S.C. 1907, I, 457.

¹⁸Ibid.

¹⁹The Commissioners were Joseph Seligman, a banker; Lewis B. Brown, a real estate investor; Cornelius Delamater, owner of an iron works; Jordan L. Mott, also an ironmonger; and Charles J. Canda, a railroad and iron entrepreneur. See New York Daily Tribune, July 2, 1875.

²⁰Report of the P.S.C. 1907, I, 458.

²¹Ibid.

²²Ibid., p. 459.

²³Ibid.

²⁴See above, n.12. The incorporators of the Manhattan Company were the investors in the New York and Metropolitan Elevated companies. They were: Cornelius K. Garrison, Horace Porter, Milton Coutright, John F. Tracy of the New York Elevated, and George M. Pullman, Jose F. Navarro, William L. Scott, David Dows, and John Ross of the Gilbert or Metropolitan Company. See Walker, Fifty Years, p. 110.

²⁵For this story, see Grodinsky, Gould, pp. 288-314.

²⁶It was in 1884 that Gould acquired control of the Manhattan Company, which was the lessor company of the two original elevated firms -- the Metropolitan and New York Elevated. It was not until 1887, however, that Gould and his ally Russell Sage were able to force Cyrus Field, the creator of the Atlantic cable and the previous owner of the New York Elevated, to relinquish his substantial shares in the Manhattan Company and to sell his stock to them. See Grodinsky, Gould, pp. 311-314.

Part I, vi

¹"History of Real Estate," p. 44.

²Grodinsky, Gould, p. 572.

³The surface railways of course competed with the "els" for passengers, but according to Mark Hirsch, W.C. Whitney's biographer, it was Whitney's opinion that "there was enough business in New York for the surface roads as well as for the elevated lines," and there was thus no reason for cutthroat competition between them. In a letter of January 3, 1891, Whitney expressed the view that "any improvement on the facilities of local transit brings an increase of population, and benefits all the local passenger railroads The elevated roads have helped to build up the town, and incidentally

the surface roads instead of being injured, have benefitted from their prosperity. . . . I have always advocated in public and private giving the elevated roads increased and improved facilities." In short, Whitney believed that the surface and elevated lines should complement rather than compete with each other. The remarks above are from a letter of William C. Whitney to Charles Anderson Dana, as quoted in Hirsch, Whitney, pp. 434-435.

- ⁴Reeves, The First Elevated Railroads, pp. 23-24.; and Grodinsky, Gould, pp. 289-290. The problem about routing was due to a mistake of the RTC of 1875. The Commissioners had authorized the New York Elevated to pass over part of a route already granted by charter to its competitor, the Metropolitan. The Board proposed that both roads build part of the structure in common, a solution which from an operating standpoint was neither practical nor desirable. The two companies worked the matter out by leasing their respective lines to the Manhattan, which took over the operation of the unified elevated system.
- ⁵Sweet, Supplemental Report relating to elevated railroads, p. 3.
- ⁶Grodinsky, Gould, pp. 288-314.
- ⁷For the 1888 figures, see the Record and Guide, XLI (April 7, 1888), 420., which cites figures from the 1887 annual report of the Manhattan Company. For the 1894 and 1899 figures, see Report of the P.S.C. 1913, V, 657., and also R.R. Bowker, "The Piracy of Public Franchises," Municipal Affairs, V, 4 (December 1901), 889.; and New York Times, April 2, 1898.
- ⁸"History of Real Estate," p. 44.
- ⁹Thirteen million dollars is the figure which George Gould himself cited to the Rapid Transit Commission in 1898. See Cheape, "Evolution of Urban Public Transit," p. 56, n.6, citing New York City, Board of Rapid Transit Railroad Commissioners, Rapid Transit Documents 1897-1904 (n.p., n.d.). The New York Times, April 2, 1898, estimated the cost to the Manhattan from abutting property suits at \$14.5 million.
- ¹⁰New York Times Editorial, November 12, 1897.
- ¹¹By 1897 Frank Julian Sprague had perfected his multiple unit control scheme for elevated railway electric traction, which obviated the need for a locomotive to pull the weight of an entire train of cars, and which made higher speeds possible. Sprague's multiple unit innovation was put into effect on the SouthSide Elevated Railway of Chicago in 1898, and six years before Chicago's Metropolitan Elevated had already converted to electricity. But Gould and Sage remained uninterested in electric traction until late in 1899, when it became clear that an electrically powered subway would become a reality. See Harold Passer, The Electrical Manufacturers 1875-1900: A Study in Competition, Entrepreneurship, Technical Change and Economic Growth (New York: Arno Press, 1972), pp. 241-242, 270-275.; and New York Times, April 2, 1898.
- ¹²Reeves, The First Elevated Railroads, p. 38.
- ¹³Whitney and Ryan introduced both cable and electric power, renovated

equipment, extended the roads, and constructed new track. They also borrowed management and organizational techniques from the railroad industry, creating a rationalized pyramidal bureaucratic structure. See Cheape, "Evolution of Urban Public Transit," pp. 71-96.; Hirsch, Whitney, pp. 421-440.

- ¹⁴ Cheape, "Evolution of Urban Public Transit," p. 105.; and New York State, Report of the Public Service Commission for the First District of the State of New York for the Six Months Ending December 31, 1907 (Albany, New York, 1908), II, 25-26 (Hereafter cited as Report of the P.S.C. 1907, II.).
- ¹⁵ Hirsch, Whitney, pp. 421-468.
- ¹⁶ Milo Maltbie, "Street Railway Franchises in New York," Municipal Affairs, VI, 1 (March 1902), 68-86.
- ¹⁷ Ibid., p. 79.
- ¹⁸ Cheape, "Evolution of Urban Public Transit," pp. 89-90.
- ¹⁹ Hirsch, Whitney, pp. 459-460.
- ²⁰ Whitney's astute understanding of public relations was shown by his concessions to public opinion in the 1890's, when the Metropolitan began to electrify its street railway system. Opinion was vehemently opposed to overhead cables for electric trolleys, which John D. Crimmins, President of the Metropolitan, proposed in 1892. Bowing to public opinion, Whitney vetoed the overhead cable and adapted the electric conduit system, in which electricity was carried through a live rail buried and covered over in a trough between the tracks. See Cheape, "Evolution of Urban Public Transit," pp. 94-96.

PART II

By the late 1880's and the early 1890's a subway for New York was an idea whose time had come. The surface and elevated railways had created more traffic than they could handle, and neither existing mode of mass transportation was able to provide rapid transit service to promote development of upper Manhattan and the Bronx. Real estate interests and many businessmen, some politicians, civic associations, labor unions, and a large majority of ordinary citizens were agreed that a subway was the only satisfactory means to meet the city's rapid transit needs. There was only one remaining question, the very large one of how to finance the projected underground road.

An answer to this question was supplied by a new force at work in European and American politics in the last decade of the nineteenth century: the movement for municipal reform. The reform movement was synonymous with an enlarged role for government. Thoughtful men were beginning to understand that great modern cities such as New York required complex and costly public works and services, which capital neither would nor could supply, and which only honest, efficient, and active government could be trusted to provide. Many American reformers hoped to emulate the example of European cities, where government, now run by able and enlightened businessmen and professional experts,¹ had raised the quality and increased the quantity of public "improvements." Writers like Richard Ely and Albert Shaw² propagated the ideas and practices of European municipal reform movements, hoping to influence American businessmen to move in a similar direction. One such idea which directly affected New York's rapid transit decision was English economist Alfred Marshall's³ method of financing public works by having the municipality pay for and own them, while the actual task of construction and operation was entrusted by lease to a private firm.

Marshall's idea had been successfully tried in Great Britain,⁴ and some New Yorkers were quick to see its advantages for financing a subway. In 1888 Mayor Abram Hewitt proposed a rapid transit plan in accordance with Marshall's method, but both business and political leaders opposed it. And beginning in the late 1880's and continuing into the early 1890's, C. W. Sweet, the erudite editor of the Record and Guide, emphasized this idea in his constant endeavor to cajole New York's businessmen and politicians to build a subway that would help develop the northern reaches of Manhattan and the Bronx. Sweet sometimes expressed his views by means of slogans such as "WHY NOT TRY THE GOVERNMENT?" and "OBJECT-LESSONS IN MUNICIPAL SOCIALISM," but this goal had nothing whatsoever to do with the doctrines of Karl Marx. What he wanted was a subway, and he saw that the best and indeed the only way to get it was through public funding. "Municipal ownership" was not a theory, but an expedient method of providing the modern metropolis with a rapid transit system commensurate with its needs.

The only 'principle' that one can safely apply to determine what a municipality should or should not do is expediency. It is that that governs THE RECORD AND GUIDE in advocating any improvements . . . Socialistic, anarchistic, and political ideas on the matter can all be subjected to the test of expediency, and accepted or rejected, as the case may be, according to how successfully they emerge from that test.⁵

Many of New York's business leaders were eager for a subway as Sweet, but they were reluctant to have the city government involved in its construction. Reformers like Sweet believed that enlarged and more important municipal responsibilities such as rapid transit construction would work against "ignorant, incompetent, and unscrupulous politicians."⁶ But most businessmen, looking to the past and Boss Tweed rather than a future transformed by reformist initiative, feared that if city officials controlled the rapid transit decision, the corrupt politicians of Tammany Hall, New York's "regular" Democratic party machine, would exploit subway construction for their own purposes. Businessmen were also hesitant to accept ideas and practices that at least to them smacked of socialism. They wanted to preserve the dominance of private enterprise in American life and its customary role in providing public transit in American cities such as New York.

In the early 1890's, then, yet another attempt was made to stimulate private capital's interest in subway construction. But as in the past, no substantial capitalist could be found to undertake the project. The opposition of the two transit monopolies, and the large capital investment they represented, deterred many substantial railroad men and financiers who might have shown an interest in the venture. Moreover, many capitalists still believed that a subway "wouldn't pay," and that, given the costs involved, it was not worth the risk. Subway construction in New York was thus repeatedly impeded and delayed because of a lack of capitalistic initiative.

By 1894 business leaders were obliged to acknowledge the validity of C. W. Sweet's "test of expediency." With great reluctance they accepted the principle of "municipal ownership," and the Chamber of Commerce of the State of New York, the most respected and powerful business organization in the city, took direction of the rapid transit decision. It sponsored a bill by means of which the city would support subway construction with its own low-interest bonds, with a private firm responsible for construction and operation of the new subway.

The Chamber of Commerce bill of 1894 represented neither a radical departure from past practice nor a victory for the principle of governmental control over public works. The bill was geared to private enterprise, and perhaps far more than C.W. Sweet or other reformers would have liked, it was an expedient measure specifically designed to overcome the opposition of capital and to attract to the subway project the kind of substantial capitalist who had not been forthcoming without a government subsidy. The Chamber of Commerce plan, as Progressive critics would later argue,⁷ promised "municipal ownership" in name only.

Nor did the Chamber of Commerce bill represent a victory for reform. The businessmen who initiated and implemented the rapid transit decision may only be described as reformers in a very special sense. Their principal desire was to reform City Hall, to eject corrupt Tammany politicians from city government, and replace the "regular" machine with men "they could trust" -- in other words, with themselves or men of similar views and social position. But they cannot and should not be confounded with another group of urban reformers, known in American historiography as the Progressives, even though the two groups were occasionally on the same side.⁸

The men in charge of the rapid transit subway decision were for the most part honest, practical, wealthy, patrician businessmen who saw that it was both necessary and expedient for them to be concerned with great municipal issues. They were not "do-gooders"; they had little sympathy for the poor, the immigrant, or the working classes occupying a social station far beneath them. And the motives behind their entry into politics were neither disinterested nor untainted by personal ambition.⁹ Unlike the Progressives, they were not critics of the unregulated and often corrupt capitalism of the late nineteenth century. Their own experience as capitalists was large, and they never questioned the wisdom of this system or the truth of its invariable "laws." Their conduct of the rapid transit decision was consistent in almost every respect with conservative and honest business practice of the nineteenth century, and "business as usual" was one of the charges that would later be made against them. Above all, they were little moved and less interested in public opinion, except insofar as it could or did affect the success of their public enterprises. They believed that substantial economic interest, social status, education, intelligence, and broad experience of practical affairs justified their claim to rule, and made popular participation both unnecessary and unwise. These attitudes and beliefs would be reflected in their activity on behalf of a rapid transit subway, and the difficult process by which that decision was implemented, as well as its final product -- the IRT -- would reveal both the virtues and defects of their point of view.

ii

At the top of the stairs leading to the Great Hall of the Chamber of Commerce of the State of New York, there is a life-size white marble statue of Abram S. Hewitt. This statue, commissioned posthumously, and a gold medal presented to the former Congressman and Mayor near the end of his life,¹ are the two tangible symbols of the Chamber's debt to the man known as "the father of the subway." The Chamber honored Hewitt for having been the first to propose the plan by which the subway was eventually constructed -- a subway funded and owned by the city, but built, leased, and operated by a private firm. The Chamber also honored Hewitt for an even more important if less specific accomplishment. He represented for its members the model of the public man, the very prototype of the patrician businessman turned politician

and reformer. One way of understanding the Chamber's political motives and activity is to understand his, for which he fortunately supplied the key. In reply to a letter from a clergyman requesting that he define his philosophy of public service, Hewitt succinctly stated the purpose governing his politics: "... the key to the work which I have tried to do in public life" is that "'Order is Heaven's first law.'"²

Abram Hewitt's love of order perhaps derived from the fact that he was not born a patrician but made himself into one; he was a self-made man of strict self-discipline and enormous self-righteousness. He overcame a background of relative poverty to become an honor student at Columbia College, a successful ironmaster, the friend and son-in-law of Peter Cooper, and member of the House of Representatives from 1874 to 1886, and Mayor of New York from 1887 to 1889. He was a distinguished and innovative businessman, who helped Peter Cooper and Cyrus Field lay the Atlantic cable, who introduced both the Bessemer and Siemens-Martin open-hearth process into the American iron and steel industry, and who, with Edward Cooper and Charles Hewitt, first perfected the manufacture of wrought-iron structural beams.³ He brought the same passion for order combined with a talent for practical innovation to public life. He fought for order against corruption in city politics as one of the leaders of the Committee of Seventy or County Democracy faction, which helped to overthrow the Tweed Ring. In 1876-1877 he led the Democratic Party in the House of Representatives in the attempt to settle the disputed Presidential election of 1876. As an enlightened industrialist, he sought to order the chaotic, strife-ridden relations between capital and labor through innovations such as arbitration and profit-sharing.⁴ And as Mayor of New York, he sought to impose order on a city where social and ethnic heterogeneity bred division, and where graft, inefficiency, and inadequate public services bred anarchy.

His rapid transit proposal was part of this design. Along with many New Yorkers in the late 1880's, May Hewitt was well aware that the elevated trains had failed to solve the city's rapid transit problem, and that the lack of adequate mass transportation was retarding the city's northern development, adversely affecting its tax base, and exacerbating traffic congestion and overcrowding below 14th Street. He knew, too, that the elevated roads would not improve their service or extend their lines of their own accord, and that other capitalists were similarly unwilling to risk subway construction on their own. He devised a plan, then, which he believed would assure the orderly development of the city, by satisfying its needs while also, or so he at least thought, providing ample profit incentive to capital.

His plan was nothing if not expedient in precisely the sense that C. W. Sweet argued for in the Record and Guide. Hewitt was a zealous partisan of private enterprise,⁵ but he was not an inflexible ideologue. If private capital would not or could not build a rapid transit system, he was willing to consider other means by which it could be achieved. And if the city could get a better deal -- lower fares, less expensive construction, and a

higher percentage of the gross return -- by paying for the road and leasing it to a private operator, he was perfectly ready to momentarily put aside the principles of economic liberalism. Thus far and no further was Abram Hewitt a "municipal socialist."

The special conditions of New York politics -- the spectre of Tammany Hall -- in his view precluded full-scale "municipal socialism" on the European model. In private letters to friends Hewitt might compare his plans for urban reform with "what was done in Birmingham, Manchester, and other English cities,"⁶ but as regards the construction and operation of a rapid transit system, he was afraid to entrust city officials with so costly and vast an enterprise.

Moreover, Hewitt's aim was to attract rather than deter reputable capital from investing in a rapid transit system. As a hard-headed businessman himself, he believed that a profit-minded capitalist, aided in the construction of a rapid transit railroad by municipal funds and credit, would show greater capacity and have better reason than city officials for running the road economically and efficiently. His plan joined the virtues of public to private enterprise, while avoiding the defects of either one: municipal funds for construction would eliminate private capital's need to resort to "watered" stock;⁷ private operation would guard against inefficiency and corruption by public servants.

It was also what some might describe as a "pure piece of legislation,"⁸ a plan that satisfied everyone's needs without taking into account the requirements of any special interest. As will be seen, this last quality was enough to assure that at least some New Yorkers -- Tammany politicians, the managers of the elevated roads, property owners -- would regard this very expedient and practical proposal as highly "impractical," and more than enough to guarantee its political failure.

Unmindful of the political problems involved, or perhaps unwilling to consider them,⁹ Hewitt drafted a message including a detailed presentation of the plan, which he delivered to the Tammany-controlled Common Council on 29 January 1888. He called for a rapid transit railroad that would measure up to the implication of its name, which meant "the ability to take passengers at the highest rate of speed . . . namely, forty to fifty miles an hour."¹⁰ There were only two kinds of roads that could provide this rate of speed, undergrounds or elevateds on sturdy stone viaducts, and Hewitt's preference was clearly for the former. As regards the heart of the plan, its financing, the City would borrow money by floating bonds for the cost of construction at a rate of three percent. It would then give over the building of the road to the New York Central Railroad, which would also lease and operate the line for thirty-five years, at an annual rental of five percent of the cost of construction. This was an amount sufficient

to pay the interest of three percent on the City bonds and also to provide at least two percent yearly for a sinking fund¹¹ that would eventually retire the bonds before the expiration of the lease. In this way, once the lease was up, the road would revert to the city free and clear.¹²

The surprising but quite understandable element of Hewitt's plan was the provision that the New York Central -- Cornelius Vanderbilt's road -- build, lease, and operate the new underground railway. The Mayor's declared purpose for choosing the New York Central was that company's control of access to Manhattan by rail, and also the fact that the City had earlier invested three million dollars in providing the Central with depressed tracks above 42nd Street. Hewitt's aim was to graft the new subway, part open-cut and part tunnel, running from the Battery to 42nd Street, onto the local lines of the Central. His undeclared motive was equally understandable. The New York Central was the only capable company presumably interested in building and operating such a road. Once again, even with public funds, the very nature of the enterprise required a reputable capitalist with large resources, and with the ability to exploit the new road to the maximum advantage. Both logic and necessity dictated Hewitt's choice of the Central; in effect there was no other choice.

The trouble was that the Mayor failed to consult¹³ with the officials of that railroad about the terms of the lease and the rules governing construction and operation. Chauncey Depew, President of the Central, quickly made it clear that his company had little interest in constructing a subway, and especially not in accordance with the terms outlined in the Mayor's message.¹⁴ As Hewitt himself would later imply,¹⁵ Depew's refusal ended any real possibility for the success of his plan.

The Mayor nonetheless stubbornly persisted in putting his plan before the public and the Legislature. He had Henry Beekman, a City's Corporation Counsel, draft a bill which was sent to Albany, and he wrote influential businessmen asking for their support.¹⁶ In his speech to the Common Council, Hewitt had pitched his argument where he as a businessman thought it would do the most good, to other businessmen concerned with the city's tax base and northward development.

The time has come . . . when the growth of the city is seriously retarded by want of proper means of access to and from the upper and lower portions of the city. Unless additional facilities are provided, the population which ought to increase at the upper end of the city will be driven to Long Island and New Jersey. Our rate of taxation depends upon the growth of the unoccupied portions of the city, particularly north of the Harlem River. This year \$55,000,000 is added to the assessed values of real estate. The result is that the rate of taxation will not be materially increased, although the appropriations are nearly \$4,000,000 greater than the year before. This increase in value

cannot go on unless the upper part of the island is provided with increased facilities of transport, . . . It therefore concerns the citizens as a whole to see that these increased facilities are provided, and it will be proper for the city itself to make the provisions, because of the increase in the value of property which these facilities will create.¹⁷

Some business groups and some of Hewitt's political allies in the County Democracy responded with strong approval of the Mayor's plan. The Real Estate, Cotton, and Produce Exchanges¹⁸ voted resolutions in its favor, and the Chamber of Commerce, which had helped draft the bill sent to the Legislature, lauded Hewitt for his non-partisanship while echoing his message's prophecy of an imperial future for New York:¹⁹ "the elimination of passion from politics happily conduces to a union of men of all parties in measure of municipal concern . . . Under the intelligent initiative of his honor, the mayor, the imperial destiny of this, the Metropolis of the Western Hemisphere, is secure."²⁰

Simon Sterne, a prominent lawyer interested in railroad regulation and reform, and an old friend and political ally of Hewitt's from the days when he, Stern, served as Secretary of the anti-Tweed Committee of Seventy, made perhaps the best case for the Mayor's plan. In a long letter to the Record and Guide, he spoke of the money the city was losing by granting perpetual franchises to corrupt and inefficient corporations like the Manhattan Company, and also pointed to the success of public projects like the Erie Canal, the Croton dam, and the Brooklyn Bridge.²¹ "We are on the threshold," Sterne wrote, "of an economic development of very considerable influence and consequence, which will modify the opinions and theories which in the past generation have exalted private enterprise and invited it into spheres beyond its proper field and limited the public machinery to narrower functions than is consistent with public interests."²²

However, Sterne's words, like the Mayor's, fell mostly on deaf ears. Some of the businessmen to whom Hewitt appealed desired rapid transit as much as he, but they disagreed with him as to the best way of obtaining it. One critic questioned the constitutionality of public ownership.²³ The Mayor's good friend, and another County Democracy ally, Orlando B. Potter,²⁴ who owned a great deal of real estate in New York, chided him for too quickly losing faith in the capacity of private enterprise to undertake rapid transit improvement.²⁵ Other businessmen lost interest when the New York Central rejected Hewitt's offer, and still others chastized him for having made the offer to this "giant monopoly" in the first place.²⁶ Even the Record and Guide, which, as might be expected, strongly favored the Mayor's proposal, nevertheless argued that he had perhaps insufficiently considered the possibility of the Manhattan Company extending its line and adding new tracks for

express service. This was of course a departure from principle, but without Vanderbilt, and with the expectation that an underground road might take as long as ten years to build,²⁷ the Record and Guide, like many proponents of rapid transit, sought more immediate relief.²⁸ Technology presented still another problem: Hewitt's proposal called for steam power at a time when other technologies -- cable-power, compressed air, and particularly electricity -- were on the point of being proven feasible.²⁹

Aside from this variety of issues, and notwithstanding the disagreements even among those advocating improved rapid transit, the principal reason for the failure of Hewitt's bill was that it had absolutely no political weight behind it. The Mayor's own faction, the County Democracy, was losing strength in both the State and the City. He had been elected Mayor in 1886 with Tammany support, which he had doubtless accepted out of ambition, but which he claimed to have accepted only because it was his duty to defeat "that socialist Henry George."³⁰ Once in office, however, he had thwarted Tammany at every turn,³¹ and he could expect no help for his rapid transit plan from that quarter, or from the Board of Aldermen which it controlled. Nor did he have any ties with Boss Platt's Republican machine in Albany, and this, plus the Manhattan Elevated Company's bipartisan collusion with both sources of political corruption, assured that Hewitt's plan would scarcely even receive a hearing in the Legislature.

There was, of course, one source of support -- the people -- that the Mayor might have tapped, but quite characteristically did not. Years later, in a letter of 1895 to tenement-house reformer Richard Watson Gilder, Hewitt would claim that his rapid transit plan was inspired by a desire to help the poor in the overcrowded slums of the Lower East Side. "So in regard to rapid transit," he would write, "my main idea was to get these people into purer air, with better surroundings at a low cost. My trouble was that I did not take the public into my confidence, mainly because I did not wish to pose as a benefactor or a philanthropist. I regarded it as my duty to improve the conditions of urban life."³⁷

Hewitt's sincerity in the above regard need not be doubted, though he was hardly what one might describe as a compassionate man, and he was never well-known as a social reformer. But there is a much more important point to make, which is that neither he nor, somewhat later, the members of the Chamber of Commerce, ever considered turning directly to the public for aid in implementing their subway plans. Both he and they hoped and expected to attract a reputable and wealthy capitalist, who failed -- or, in the case of the Chamber's effort, very nearly failed -- to come forth. Both his and their obsessive fear of Tammany precluded their developing appropriate lines of political patronage. And neither he nor they made any attempt, indeed they discouraged every attempt, to cultivate or mobilize popular support. This helps to explain why it would take twelve more years before the plan for which the Chamber eventually honored Abram Hewitt would become a reality.

Abram Hewitt lost two battles in 1888; his rapid transit bill was defeated, and he failed to be re-elected Mayor of New York. He at first declined to stand for a second term, but finally ran¹ on an Independent ticket against the Tammany candidate, Hugh Grant,² who soundly defeated him.

Patrician reformers then and afterwards would claim that the Tammany hiatus between Hewitt's mayoralty and the victory of Reform candidate, William Strong, in 1894, stalled action on behalf of an underground road and put an end, at least for a time, to the possibility of a publicly funded rapid transit system. The Record and Guide, no friend of Tammany's, but an impartial critic of Hewitt's conduct as Mayor, thought otherwise. It described Hewitt as the best of his kind, "probably the ablest chief magistrate this city ever had," but added that sometimes his kind was not what was wanted: ". . . he was too brilliant a man for the position. He was cranky, erratic, and, in many respects, impracticable. He was at fault on such . . . subjects as rapid transit." Compared with his erudite predecessor, the new Tammany -sponsored Mayor could not be expected "to write as brilliant letters and messages," but he could be expected "to help along more efficiently than Mr. Hewitt needed public improvements."³

Tammany control of City Hall presented no insuperable obstacle to the realization of C. W. Sweet's goal, which was more and better rapid transit. Sweet of course acknowledged Tammany as a problem, but he believed that the Tiger had grown tamer, or was at least better trained than in the days of the Tweed Ring: "fraudulent speculation" and "deliberate stealing" were rare; and "Richard Croker and his assistants have evidently been doing their best to reconcile the interests of Tammany with those of the city."⁴ "The new mayor," argued the Record and Guide, "will take care of Tammany Hall as a matter of course, but his first duty is to the people of New York City. We want more rapid transit -- some better means of getting up and down town by vehicular traffic, both on the east and west sides."⁵

The Record and Guide was once again proven right. Hugh Grant did his best for rapid transit. And though what he was able to do fell short of the desired goal of subway construction, one indirect result of his activity was that influential segments of the public began to swing towards the idea of an underground road funded by the city. Tammany did not lead but rather followed the course of public opinion, and since public opinion feared governmental and favored private enterprise, Hugh Grant tried to provide capital with its best and last real opportunity to build a subway on its own. Once this effort had failed, through no fault of his or Tammany's, the way was open to municipal ownership, and thus Abram Hewitt, who in 1888 had lost the first battle, was able in 1894 to win the war.

It was not Tammany but the business community, the transit monopolies, and Broadway property owners who slowed the progress of the rapid transit decision. Business leaders wanted rapid transit, but they could not agree among themselves what form it should take, or whether it should be a private or a public venture. The transit monopolies -- the Manhattan Company and the Metropolitan Railway -- did their best to add to and profit from this confusion, and were generally negative in their response to any suggestion of private underground railway construction, much less a subway owned by the municipality. The Broadway property owners kept in the background, maintaining a discrete but effective silence. The mere mention of a Broadway route -- the only conceivably profitable one -- was sufficient to raise the spectre of their opposition, thereby discouraging any capitalist who might come forth to do the job.

Some idea of the division among business leaders on the rapid transit question can be derived from two series of interviews conducted in March 1889 and again in May 1890 by the Record and Guide. The first straw poll was taken in regard to the Manhattan Company's proposal to annex part of Battery Park, the southern terminus of the line, for a switching yard and loop that would permit their trains to accelerate the return trip north. A few prominent businessmen were adamantly against the Manhattan proposition, on the grounds that it would mar the Park, and, more important, that it would not materially affect the speed or service of the elevated trains, despite the Company's assertions to the contrary. These opponents of the proposal spoke of "a more permanent solution of the rapid transit question," and usually mentioned underground road, particularly the Arcade railway plan for a road directly under Broadway.⁶ Many businessmen were willing to allow the Manhattan to have whatever it asked for, in the hope and expectation that this would provide the city with some measure of immediate relief. But even this group recognized that sooner or later the existing elevated roads would have to be supplemented or altogether replaced by an underground line or a viaduct railway.⁷

Others thought that extension of the existing elevated lines would suffice for the future rapid transit needs of the city. For example, Alexander E. Orr, President of the Produce Exchange and later President of the Chamber of Commerce and Chairman of the Rapid Transit Commission of 1894, was wholly in favor of the Manhattan's request. Considering the important role that Orr would subsequently play in promoting and implementing municipal ownership of an underground road, his remarks are worthy of note. "I think Mr. Gould's ideas," he said,

... are exceedingly valuable to the people of this city. Individually, as a citizen, I would willingly grant the Manhattan Road any extra facilities which they may think necessary to the development of their lines for the convenience of the public. The officers of that road were courageous enough to build and extend

their system to accommodate the upper parts of the city where it did not pay them to run, and they should be the first to be given an opportunity to see what they can do for the people . . . I think the present system of elevated roads can be made to meet the requirements of the next five or ten years. As to a future plan I don't favor an underground plan, nor do I think a road through the blocks will do. Such a road would have to charge too high a fare to obtain remuneration on the immense cost of buying the right of way and constructing the railroad of solid masonry.⁸

The question posed in the second straw poll was whether private capital or the city itself should undertake rapid transit construction. Some businessmen raised no objections to either municipal ownership or construction. Others favored public ownership, but followed Mayor Hewitt's plan to give over construction and operation to a private company.⁹ Most businessmen were against the city owning or building the road. A few opposed municipal involvement on the purely ideological grounds that such a proposal presaged "paternalistic government."¹⁰ The majority was fearful of allowing Tammany to obtain control of so costly and profitable an enterprise. Typical of these responses were the remarks of V.K. Stevenson, identified as a "large property owner":

. . . in view of the short duration of each Mayor's term in office, the vicissitudes and changes in politics, and also of the fact -- which I am heartily in favor of -- that our adopted citizens having the right to vote, many of them not speaking our language fluently, are imposed upon by designing men, who slip into office at intervals, which is radically disadvantageous to good city government, and also in view of the fact that the more financial undertakings and obligations the city assumes, the more chance for fraud and financial entanglements, adverse to the interests of taxpayers. I think that for the city to undertake the building of a rapid transit railway would be ridiculous.

These responses of course reflect one of these brief periods in the last two decades of the nineteenth century when the Manhattan Company and its elevated roads seemed to offer if not the best at least the only hope for improved rapid transit; the attitude of most businessmen was to regard the Manhattan as a last resort chosen out of desperation. Yet it is difficult not to notice the fact that many business leaders were more than ready to overlook the faults of the Manhattan, but were preoccupied with the potential danger that might ensue from Tammany, should the city own or build a rapid transit road.

It is no simple matter to discern the reasons for this excessive fear of Tammany. Past experience alone cannot explain it, though the Tweed Ring and other lesser scandals surely helped to foster this attitude in patrician businessmen. Politics also played its part. As Abram Hewitt's County Democracy and A. E. Orr's reform political faction in Brooklyn demonstrate, patrician businessmen often had political as well as ethical motives for opposing Tammany; when Tammany was "in," they were "out."¹²

Yet something more than either memory of Boss Tweed or mere political factionalism was involved. The obsession with Tammany was a kind of smokescreen which permitted patrician business leaders to shrink from facing facts they had no wish to confront, and from placing blame where it really belonged -- on the system of unregulated capitalism to which most of them adhered. It was easier and far more comforting to condemn Tammany, than to question one's own assumption or one's own business associates. It was less difficult to reject municipal ownership or construction because of possible Tammany corruption, than to acknowledge that the solution to the problems of the city and its people required the acceptance of new principles and also new rules for business organization and performance. Men like C. W. Sweet and Simon Sterne harbored no illusions regarding Tammany, but in their desire to find practical and expedient solutions to the city's problems, they modified their attitude to "bossism.: It was not necessary to forget "the great frauds and malversations of the period 1868-1871," in order to see that a rapid transit railroad, like the Erie Canal, was more than worth its small cost in corruption.¹³ This was a lesson which most patrician businessmen were unwilling to learn, and their failures in this regard would have its effect in shaping the final outcome of the rapid transit decision.

For Tammany Mayor Hugh Grant, however, there was no choice but to further that decision in whatever way he could. Faced with division and confusion among business leaders, he sought some way to reach firm conclusions and an acceptable solution of the rapid transit. He attempted to alter the Rapid Transit Act of 1875, appointing a new Commission with enlarged powers, a staff of experts, and a longer term of office.¹⁴ Suspicion of a rivalry with Tammany, however, was not confined to patrician businessmen. The Republican machine in control of the Legislature feared that Tammany might profit politically from the creation of a new rapid transit system, and Grant's bill was therefore stalled for two years in Albany.

In the interim the Mayor appointed a group of businessmen to yet another Commission under the old law.¹⁵ This Commission, composed of August Belmont (Sr.), William Steinway, Charles S. Smith, John H. Starin, and Orlando B. Potter,¹⁶ was a distinguished and patrician group of businessmen as could be found. But as their report concluded, they had little power to do anything towards rapid transit improvement. The principal problem was that no suitable routes were available. As the Times put it, "... it was found that the statutes had been so manipulated -- that no railroad could be

constructed under or over any existing elevated railroad structure, or across, over, or under, or through Broadway, Fifth Avenue, Forty-second street, the Boulevard, West End Avenue, or any of the streets bounding Morningside or Riverside Parks (except Tenth Avenue and One Hundred and Tenth Streets)."¹⁷

This Commission and the one which followed it in the latter part of 1890, composed of Steinway and Starin of the first board, and with the addition of Samuel Spencer, Eugene Bushe, and John H. Inman,¹⁸ did, however, serve a purpose. Boss Platt and the Republicans in Albany were impressed and somewhat placated by the bipartisan distinction of Grant's nominees, and this, in conjunction with widespread popular and interest-group agitation¹⁹ for the passage of the Mayor's bill, resulted in the Legislature's approval in the Spring of 1891. The new Act disposed of the six month time limit in the old law, and established the Commission for an indefinite duration. This provided the new body, unlike prior boards, with a sufficient period in which to consider alternatives to the existing modes of transit. The new law, like the old, accorded the Commission the power to chart routes, decide on motive power, devise plans for construction and operation, obtain the consent of property owners or, failing this, of the Supreme Court, and establish the terms on which the franchise was to be auctioned. The Board was also empowered to grant additional franchises to existing railroad companies.²⁰

With the aid of these two experts, the RTC set to work and quickly concluded, even before the passage of the Mayor's bill, that an underground four-track railway would provide the only viable solution to New York's mass transit problem. It took somewhat longer to decide on the matter of the most suitable route, the type of construction, and the most feasible motive power. By May 1891 the Board was prepared to write its report to the Mayor and Common Council. The obvious route was chosen for being the most profitable one -- through Broadway from South Ferry to 59th Street, then through the Boulevard (upper Broadway) to 169th Street, and finally through Eleventh Avenue and over the Spuyten Duyvil creek to the northern limits of the city. A branch route on the East Side, beginning at 14th Street and going up Fourth, Park, and Madison Avenues to the Bronx was also proposed. Given the possibility of a shallow, intermediate-level, or very deep tunnel, the Commission opted for the first alternative, calling for construction of a shallow or "Arcade" tunnel²³ directly below Broadway in the downtown area, which would then become a viaduct railway at selected points in the less populated northern sections of the city. Deep tunnels were rejected because they are more costly to construct, and, perhaps even more important, steep stairs on long waits for elevators might discourage downtown area short-trip passengers, upon whom the initial success of the subway would depend.²⁴ There was some disagreement between the two engineers as to whether the road should have four tracks all on one level, or whether the express tracks should be located below the local tracks. The Commission preferred the former alternative, again to encourage short-run traffic. As regards motive power, the decision was for some form "secured without

combustion in the tunnel," which, as the RTC indicated, ruled out steam and probably meant electricity. Inasmuch as electric power had not yet been proven feasible at the required speed of forty miles an hour,²⁵ the question was left for further consideration. The cost of the enterprise was estimated at \$50,000,000.

In reaching its conclusions the RTC was faced with a dilemma which was the result of two contradictory purposes. It saw itself as under the obligation "to lay the foundation for . . . a broad and comprehensive system of rapid transit" that "would meet the needs of the city at present and be capable of expansion in the future."²⁶ Unlike the RTC of 1875, it refused to choose only that which it knew would be most attractive to capitalists. It met its obligation by proposing a rapid transit system as comprehensive as and almost identical to the one put forth by the Senate Committee of 1866. At the same time it did want, indeed its most important task was, to tempt a capitalist or capitalists with sufficient means to buy the franchise and build the subway. All of its engineering decisions -- an underground road rather than an even more expensive viaduct railway,²⁷ shallow tunnels, non-cumbustive motive power, four tracks on one level -- as well as its choice of a lower Broadway route, were designed to fulfill this second duty. And despite criticism from newspapers and reformers,²⁸ its offer of the franchise for a term of 999 years was made with precisely the same aim in mind. The two purposes, however, were mutually exclusive. The needs of the city and the requirements of private capital did not and could not be made to coincide. When the franchise was offered for sale in December 1892, there were not reputable bidders.²⁹

Several reasons explain this rather pathetic failure after so much good will and hard work. In the early 1890's subways seemed more than ever a costly and not necessarily profitable innovation. In the 1860's the first steam-powered subway in London had offered New York a precedent which, comparatively, was far more promising than the first electric subway, the City and South London Railway, completed in 1890, which was not only unprofitable but also too slow to meet New York's needs.³⁰ The RTC of 1891 also added to the franchise certain restrictions, which may have discouraged prospective bidders. It determined the fare uniformly at five cents; it mandated completion within five years or forfeiture of a three million dollar security bond; and it requested the full amount of the bid thirty days after the auction. Never to be discounted, of course, was the matter of necessary permissions from Broadway property owners, more than half of whom had not even responded by the time that the franchise was offered for sale.³¹

Leaving aside this last problem, which would not be resolved until a route other than Broadway was chosen, everything else might have easily been overcome, were it not that a comprehensive underground system was very costly, and that so much money was already invested in existing modes of transit. In addition the two transit monopolies -- the Manhattan and the Metropolitan -- were actively engaged in dissuading investors from the subway venture.

Early students of the subject like Robert Brooks, Clarence McNeil,³² and James Blaine Walker too readily accepted the view of a "reform" rapid transit expert like William Barclay Parsons, who claimed that the RTC of 1891 was a "Tammany Commission."³³ All the evidence, however, belies Parsons' assertion. His remark is interesting only because of what it neglects to say -- that is, if Tammany did have anything to do with the RTC's failure, its role was far less significant, and it was at the very worst merely the humble servant of those parties with a real interest in the matter, the two transit monopolies.

The Record and Guide was not as reluctant as Parsons to call a spade a spade. It not only identified these parties, but also left no doubt as to the immense power -- the web of financial and political connection -- which they enjoyed.

Between the Manhattan' Elevated Railway Company and the Metropolitan Traction Company there is a perfect unity of sentiment regarding the projected underground road. It is needless to say that it is not a friendly sentiment. From no person identified with either the Manhattan . . . , owner of all the elevated roads, or the Metropolitan . . . , owner of nearly all the important surface lines, has a friendly word ever been heard or can a friendly sentiment be expected towards the underground railroad enterprise. This is only natural and was to have been expected. But without a knowledge of the personnel of these companies there can be no adequate conception of the ramifications of this adverse sentiment (my italics). In the Board of Directors of the Manhattan . . . are George J. Gould, now the President . . . ; J. Pierpont Morgan of Drexel, Morgan, & Co.; Sidney Dillon, Robert M. Gallaway, President of the Merchant's National Bank; Edwin Gould, Russell Sage, Samuel Sloan, Simon Wormser, Chester W. Chapin, and George Bliss. In the Metropolitan . . . , owner of the Broadway and Seventh Avenue, Sixth Avenue, Ninth Avenue, Belt Line, Avenue D, Houston, West Street and Pavonia Ferry, Bleecker Street and Fulton Ferry, Chambers Street, Cross-town and other surface lines, are William C. Whitney, ex-Secretary of the Navy; Col. Daniel S. Lamont, former private secretary to President Cleveland; John D. Crimmins, Thomas F. Ryan, Thomas J. O'Donohue, and Wm. L. Elkins and Peter A. B. Widener, of Philadelphia . . . In addition to the influential array of directors of the two companies above mentioned, there are also several hundreds of stockholders in both corporations, embracing a very large proportion of the investing class of the city's population, who are all the more potential in directing and supporting the policies and purposes of those corporations because they are not publicly identified with them (my italics).³⁴

Considerations such as these point to the real if indirect accomplishment of the RTC of 1891. It demonstrated that private capital would not and, in the light of the powerful opposition of the transit monopolies, could not, construct an underground rapid transit system. For two more years the Commission continued in vain to dicker with the Manhattan Company for extensions of its lines and improvement of its service. Acting under the restrictions of its legal mandate, it had no other choice.

But even before the franchise was unsuccessfully offered at auction, other parties were busy promoting alternatives to private capital. A "reform" newspaper like the Times and a business group such as the Real Estate Exchange and its spokesman, the Record and Guide,³⁵ were of course eager for a new rapid transit system, and had long before come out in favor of municipal ownership and/or construction. Other businessmen hesitated to accept this principle, but they did take a first step towards it by proposing the loan of city credit to a private corporation.

As early as March 1891 banker Jacob Schiff told the RTC that he seriously doubted that private capital could be found "for building a road that would probably cost some five millions of dollars a mile, and upon a return of five cents for each passenger." At that time he urged the city to construct the road on its own, supervised by a group "of businessmen of universally acknowledged integrity and capability," and then, as Abram Hewitt had suggested and as the citizens of Cincinnati had done with their Cincinnati-Southern Railroad,³⁶ to lease the railway to a private operator. With city credit secured at three percent rather than private credit obtained at ten or twelve percent after stock "watering,"³⁷ the projected underground road, even with a uniform five cent fare, would offer ample profit incentive to both the "financial community" and a private lessee.³⁸

Once again, however, Schiff's peers in the "financial community" expressed grave reservations about municipal ownership or construction. They raised two kinds of objections -- financial and political. On the financial side, they argued that even with city funds for construction, a private operator would not be willing to put down money for a subway scheme that would permit the city to own the underground road outright within thirty-five years. The road might not be an initial success, the fare was too low, and the cost of rolling stock, equipment, and the interest on city bonds plus provision for a sinking fund, would eat away whatever small profit might be made. The failure of Abram Hewitt's plan in 1886, they said, sufficed to demonstrate that private capital was not attracted by the offer of public funds, and that Vanderbilt, Depew, and others had seen no chance of profit from the scheme. They also believed that it would be risky for the city to invest its money initially in an enterprise that might fail, and then find itself left with an unfinished road and a huge debt. Moreover, on the off-chance that the road should be successful, it would in the long run be better if a private company were to build it. Private capital would have greater reason to exploit success than the city, and a private firm would quickly expand and

develop the system.³⁹ Of course all of these reservations boil down to an essential one, which was simply expressed by William Barclay Parsons, the rapid transit consultant for many of these same businessmen: "I am opposed to all socialistic tendencies. It seems to me that the function of government is to govern, and not to manufacture gas, operate railways, or do other things which are the functions of a private corporation."⁴⁰

The business community's greatest fear, however, had to do with politics, with the likelihood that municipal ownership would somehow involve Tammany, which in its view simply could not be trusted with such a venture. Alexander Orr, for example, acknowledged that he had supported the plan for municipal ownership that Mayor Abram Hewitt had sponsored, but that he would not support a similar plan proposed at a time when New York was governed by Tammany. "I should hold the same opinion still," he said, ". . . provided we had men at the helm of our municipal affairs that we could trust, but as this is not now the case, nor is there any prospect that we soon shall have, I could not and I would not . . . put myself on record . . . to recommend that the city should build this much needed system of rapid transit . . . to be controlled by the power which controls the municipal government of the City of New York."⁴¹

In 1894 R. T. Wilson, a prominent banker, came before the Chamber of Commerce with a plan which seemed to give private capital precisely what it wanted: city funds without interference from corrupt city government, and a private corporation to construct, operate, and most important, own the road. Wilson asked the Chamber to sponsor a bill by which the city would loan his private syndicate up to two-thirds the cost of construction not exceeding \$30 million, with his syndicate putting up the first third and taking the risk of beginning to build before the city spent a cent. Almost all the members of the Chamber were enthusiastic about the plan, even Jacob Schiff, who mentioned "very dangerous reasons" that were better not discussed -- that is, Tammany -- in order to explain having disavowed his 1891 proposal for municipal ownership.⁴² And almost everyone agreed that Wilson's plan provided ample incentive for a private operator, future investment opportunity for other capitalists, little risk for the city, and, best of all, the promise of a privately owned and operated railway that Tammany could not touch.

Almost everyone, that is, except old Abram Hewitt. The former mayor and aged leader of the County Democracy was a very complex man, and he had in mind a complex strategy that he did not fully reveal in his impassioned orations before the Chamber.

In speaking to that body he referred to the examples of the Union Pacific Railroad and the Brooklyn Bridge, to show that partnerships between government and private corporations were often abused and frequently turned out badly.⁴³ He also reminded the Chamber that such a use of city money as Wilson's plan suggested, was prohibited by the State's constitution, and that any attempt to

repeal this prohibition or amend it in the interest of this special case, would both be wrong and would lead to interminable delay.⁴⁴

To his credit, the old Mayor believed that the city should eventually own the projected underground road outright. He had had his fill of the Manhattan Elevated Company and the Metropolitan Traction Company, upon whom he sometimes laid the blame for the defeat of his 1888 plan.⁴⁵ As he told George Foster Peabody, he thought the State should constitutionally disallow franchises granted for more than fifty years.⁴⁶ With respect to R. T. Wilson's plan, he wrote Morris Jessup that "the city might just as well retain the ownership of the property and have its ultimate control, as to give it away to Mr. Wilson and his friends."⁴⁷

Hewitt did not rely solely, however, on moral or legal arguments. He knew that the problem was to find a way to induce capital to go along with municipal ownership, and he managed this by means of a strategy that combined the carrot with the stick.

The carrot was something new. It is often said that Hewitt's plan in 1894 was identical, save for inclusion of the New York Central, to the proposal he set forth as Mayor in 1888. But there was an important difference between the two plans. His 1888 bill called for a five percent yearly payment on the cost of construction, so as to pay for the three percent interest on city bonds and provide two percent for a sinking fund which would pay off the city's capital investment before the expiration of the operator's thirty-five year lease. In 1894 Hewitt proposed a four percent yearly payment on the cost of construction, which may not seem like a great deal, but which in fact was quite significant. With a four percent yearly payment -- three percent for the interest on city bonds and only one percent for the sinking fund -- the bonds would be retired at a later date, and the lease would be longer. This in itself, at a time when no one knew for sure if the subway would be initially successful, offered some incentive to a private operator, who would have more time to garner profit from a railroad which might at first pay poorly. In addition, a four percent rate of interest on the cost would give the lessee who built the road an almost certain guarantee of immediate profit on construction, from which he could afford to pay for the cost of equipment and rolling stock. He would therefore require virtually no capital to commence the enterprise, and if the venture proved successful, what he earned over the course of fifty years of operation would be taxes at a rate -- four percent -- much below what he could have expected had he built the road on his own.⁴⁸

The stick that Hewitt brandished was the competitive threat of subway construction in line with his plan. He believed that the very possibility that some substantial capitalist might accept his deal, would induce companies like the Manhattan or Metropolitan either to compete for the lease themselves, or, failing this, to do something in the way of improving or extending their

lines in order to forestall competition from a new subway company. Hewitt was convinced that if the city played its cards correctly, the threat of competition would stimulate activity from some quarter, and if not from a new source of capital, then from the established transit monopolies. "I can understand," he told the Chamber,

. . . that the Metropolitan Traction Company, which has the cable route on Broadway and roads on other streets, would find it very much to their interest to control the rapid transit movement, because of their admirable situation for local distribution from the points where the rapid transit system would necessarily stop its trains . . . I take it that the Manhattan Railway Company would be very unwilling to see the franchise pass from under their control, when they knew it was to be constructed. And so far from not having competition, I fancy the difficulty will be with the number of competitors that will appear, not only from this city but from elsewhere, to bid for the construction and the control of this great work.⁴⁹

In the spring of 1894, Hewitt was not merely assuming but was in fact certain that there would be at least one bidder and perhaps considerable competition, and this was the best, the last, and the surprise card which he dealt to his dubious colleagues in the Chamber of Commerce. They were reluctant to turn away R. T. Wilson, for his, after all, was the first substantial offer made by private capital after years of fruitless schemes. To persuade his fellows at the Chamber of the soundness of his proposal, Hewitt needed an offer better than Wilson's, and one which was specifically tied to his plan. In speaking to the Chamber he alluded to "one leading railway company, not the New York Central," which was ready to bid on the contract should his scheme be adopted. Privately, in a letter to his friend Morris Jessup, he revealed that this offer came from an eminently responsible source -- Austin Corbin, President of the Long Island Railroad.⁵⁰ This was enough to do the trick. The Chamber rejected R. T. Wilson's plan, approved Hewitt's substitute proposal, and became the sponsor of a bill providing for municipal ownership.

At this point something happened for which the business elite of the Chamber were not prepared, and which anticipated future events. In their deliberations they had not considered public opinion, nor did they seek popular support. But much to their chagrin, they nevertheless found themselves saddled with it in the form of a piece of legislation, the Butts-Lexow bill, which was similar to their own insofar as it called for public ownership, but which made this principle dependent upon approval by a popular referendum in the coming November election.⁵¹ The Butts-Lexow bill was sponsored by the Central Federated Labor Union and its eighty-three member unions, who hoped subway construction would generate employment in the midst of the national depression that began in 1893. It represented an attempt by labor to have a voice in matters directly affecting it, and was a rare but significant expression of popular sentiment for rapid transit.

Hewitt and several other business leaders went to Albany, both to lobby for their own bill, and also with the express purpose of defeating the Butts-Lexow legislation. They achieved the latter aim by making it seem as if a clause in the labor bill prohibiting future construction of elevated roads, in fact guaranteed a transit monopoly for the Manhattan Company.⁵² In addition, Hewitt described the labor unions' bill as "anarchical," and implicitly compared it with recent tragic events such as Coxey's Army.

Now we come to the question of the referendum. In three states in this country we have seen within a fortnight insurrections of the most destructive character. Our friends of the labor union don't see that this referendum question is leading to anarchy. The men who are back of this movement had no idea of preserving or protecting, but of destroying, property and vested rights . . . Now, so far as the Chamber of Commerce is concerned, we would prefer to go without rapid transit for a generation rather than to have this insidious question of referendum injected into the bill.⁵³

Despite Hewitt's threat, however, the Chamber could not withdraw support from its own bill, and the labor unions steadfastly refused to accept the business elite's bill unless it was amended to include a popular referendum. Thus modified, the Rapid Transit Act of 1894 was passed by the Legislature, and signed into law by Governor Flower on May 22, 1894.⁵⁴

The labor union amendment gave Hewitt and the Chamber of Commerce an Act which was not precisely what they wanted, and, as things turned out, not what they needed. Its first effect was to discourage Austin Corbin and his syndicate, who chose not to engage either their energies or their money in a subway scheme which would have to be postponed until the referendum in November, and which would then depend upon the vagaries of the popular will.⁵⁵ Hewitt was bewildered, disconsolate,⁵⁶ and not a little embarrassed at his failure to deliver a deal that had in all probability been the principal motive for the Chamber's acceptance of his proposal over Wilson's. And with the exception of Seth Low, President of Columbia College, who was unreservedly in favor of public ownership,⁵⁷ the other conservative businessmen of the Chamber of Commerce specifically named in the Act as Rapid Transit Commissioners -- Alexander Orr, William Steinway, John H. Starin, John Claflin⁵⁸ -- were left to implement a law embodying a principle which none of them had at first supported, and which, to say the least, they regarded with ambivalence.

Still, there was some consolation in the fact that the Chamber of Commerce was now clearly in a position to oversee activity in behalf of a rapid transit underground railroad. The labor union amendment had perhaps delayed things, but there would doubtless be other capitalists with intentions similar to Austin Corbin's. And the referendum vote in November -- 132,647 in favor of, 42,916 against, municipal ownership⁵⁹ -- was useful as confirmation of

the mandate of the Commission, which would be exercised with as little regard for popular opinion and as free from popular interference as possible. Nor would or could there be, or so the new Commissioners thought, any interference from city officials. The Mayor and the Comptroller were of course ex officio members of the Board, but only six votes were needed to carry any motion, and the Chamber of Commerce representation on the RTC outnumbered city authorities by six to two. So long as the Chamber of Commerce was in charge of the situation, there need be no conflict between the demands of public and private enterprise. The principle of public ownership would be applied sanely, flexibly, and in a manner that recognized both the needs of the city and the legitimate interests of private capital. The nefarious interests of Tammany would be avoided. There would be no opportunity for its district leaders and ward-healers to line their pockets.

The November election had at any rate eliminated this last problem, at least for a time. Patrician reformers, among whom many of the members of the Chamber and RTC figures prominently, and the Republican organization of Boss Platt had united on a Fusion candidate for Mayor, who was one of the Chamber's own, in fact a Vice-President of that body, Colonel William L. Strong. And in what Samuel McSeveney has described as the "midterm upheaval" of the 1890's, in which Republicans exploited the depression to overcome a quarter of a century of political stalemate,⁶⁰ Strong had won the Mayoralty and sent Boss Croker packing. The new RTC thus began its work in the most auspicious circumstances, with a city administration composed of men whom it could trust. Things looked good; the large caption on the front page of the Record and Guide in October 1894 read: "RAPID TRANSIT AT LAST."⁶¹

Appearances were deceiving. Tammany would be back, and with a very long memory regarding the men and institutions that had encouraged its momentary exile. In the interim the RTC would get itself into sufficient hot water with Broadway property owners and the courts to have no need of Tammany in order to feel itself beset by evil forces. Its difficulties would discourage any capitalist of substance from coming forth, and it would be compelled to deal or at least talk endlessly with the old monopolies -- the Manhattan and the Metropolitan. Upon Tammany's return there would be new problems, some real -- the city debt limit -- and some contrived to suit Boss Croker's pleasure. For the patrician gentlemen of the RTC, Croker's Tiger would once again bare its claws. The Commission's independence of Tammany was an affront to his self-respect. And the eminently respectable members of the Commission were themselves too conservative, too hidebound in their anti-labor, anti-immigrant, anti-"socialistic" prejudices,⁶² to conceive, much less initiate, a union of reform and machine that would later provide what John Buerker describes as "bread and butter" urban liberalism -- the heyday of urban reform under such men as Joe Tumulty and Woodrow Wilson, Charles Murphy, Ed Flynn, Al Smith, and Robert Wagner, Sr.⁶³

In the end the public and the labor unions would once again surprise the Chamber and the RTC, and foil their plans, but this time very much for their own good and for the good of the rapid transit subway decision. But by that time -- six years hence -- the new RTC would have become known as the old RTC, and the Commissioners themselves would fit the description of Mayor George B. McLellan: ". . . they [the RTC] were a group of very worthy old

gentlemen of large business experience but extreme old age, who nevertheless seldom died and never resigned."⁶⁴

iv

At the end of 1901 the Rapid Transit Commission established by the Act of 1894 prepared for the Mayor of New York "a detailed and authentic account" of the long process which culminated in the construction of the IRT. The report was written by Edward Shepard, the Brooklyn reform leader and counsel to the Commission, who then sent it on to the members of the Board for their final recommendations and approval. George Rives,¹ another prominent lawyer appointed to the Commission in 1896, was delighted with the report, and sent Shepard a note in which he clearly caught the tone and meaning that the latter intended it should have: "The history of the present Commission," Rives wrote, ". . . is really a most gratifying reconstruction of a successful struggle against stupidity, cupidity, and indifference, and it seems to me to reflect the greatest credit upon all who have been on the winning side."²

As with all such accounts, "truth" depends upon who is doing the telling and who is doing the reading. Suffice it to say that the RTC's version of the story leaves a great deal unsaid, and that the "authentic" history is far more complex than Shepard's or Rives' view of good guys versus bad guys would lead one to believe.

The six years between 1894, when the RTC set to work, and 1900, when the contract for construction of the IRT subway was signed, witnessed a rerun of all the difficulties that had stood in the way of a subway in both the distant past and in the period since Mayor Hewitt's plan of 1888. The promise of city funds for construction did not eliminate the old problem of the subway's excessive cost. The Commission's first plan was for a subway system that was beyond the means of the city, and also in excess of the cost limit of \$50 million imposed by the Act of 1894.³ Its second plan met the cost restrictions of the Act, but was not implemented because of a new money problem, the question of the city debt limit subsequent to the consolidation of Greater New York. As before, the RTC also had difficulty in finding a substantial and reputable capitalist willing to undertake construction and operation of the subway. Some still believed that a subway "wouldn't pay," but just as important as this was the fact that the two great transit monopolies -- the Manhattan Elevated Company and the Metropolitan Traction Company -- which controlled the elevated and most of the surface trolley lines, continued to do their best to discourage any new entrepreneur from invading their territory. Again, Broadway property owners also played their part in delaying and, as it was thought for a time, nearly precluding the subway decision.

All of this points to an important fact which the Commission's account of its own achievement understandably never mentioned. That is, the subway decision had always been and, almost until the end, remained a decision in which only New York's elites were involved. The problem with this was that

the elites -- the transit monopolies, Broadway property owners, the business community generally, patrician reformers, and Tammany -- were divided and sometimes indecisive, and could not agree among themselves on a common policy to resolve the transit problems and meet the transit needs of New York.

The two elite groups most importantly involved in the decision, the patrician reformers of the Chamber of Commerce and RTC, and the Tammany men who ran the city government, might together have successfully tackled the many obstacles and other elites who stood in the way of subway construction. But in the last years of the nineteenth century these two groups were virtually at war with each other. The inflexibility of both groups, their refusal to forget past grievances, their incapacity to recognize each other's legitimate interests, their mutual suspicion, made it impossible for them to establish lines of communication and patronage which alone would have allowed for the successful conclusion of the subway decision. On its side Tammany would have nothing to do with the RTC; and the RTC, though expressing willingness to deal with city officials, would only do so as long as direction of the rapid transit decision remained firmly in its hands or in the hands of other men "whom it could trust." Both groups sometimes seemed to consider their struggle with each other almost as seriously or perhaps more seriously than their responsibility to the public. Fear of Tammany had long prevented the business and reform elite from accepting the principle of public ownership; the battle with Tammany held up the attainment of the subway even when this principle was reluctantly accepted.

Had the decision been left to the elite groups alone, the IRT subway might never have been begun, or would at least have taken even longer to achieve than it did. Happily for New York, by the late 1890's a new party was ready to make its voice heard in the rapid transit subway decision. At the turn of the century poor, immigrant, and working-class New Yorkers, like similar groups in other American cities, were beginning to understand the political world in which they lived, and were learning how to use both reformers and machine politicians to serve their own purposes.⁴ The significance of the subway decision is that it was one of the first major decisions in New York that in the end was really made not by one or another of the elites, but by the public itself. One need not be a sentimental populist to see that it was its great need and its overwhelming demand for the subway, which finally compelled the divided elites to settle their differences and do what had to be done for the city and its people. The decision for the IRT subway was not, as Rives, Shepard, the RTC, and financier August Belmont believed, a singular triumph for patrician reformers and businessmen, but rather one of those rare historical instances in which the public won a great victory. A laborer by the name of E. J. Hawks, whom the Times described as "a broad-shouldered working man," put the matter both succinctly and well when he spoke before the Commission in 1896, at an especially low point in its fortunes: "You want someone behind you all the time," he said, "someone to push you along and give you nerve."⁵

The new RTC convened for the first time on June 8, 1894. Its first task was to prepare itself quickly for the November referendum, which it easily accomplished by re-adopting the underground railroad plans and routes of the Commission of 1891, but with the proviso that a complete review of the latter body's work would follow upon a favorable popular vote. To facilitate this review de novo, it sent its Chief Engineer, none other than William Barclay Parsons, to Europe, directing him to make a complete and comparative study of those British and Continental rapid transit systems that might bear directly on New York's situation.

Parsons returned to New York early in October 1894 with a carefully written and well-documented report, which was largely responsible for the Commission getting off to a good start. From the outset the Chief Engineer's role in the Commission was not limited to the background position of a strictly technical advisor. As was consistent with his own vision of the engineer's comprehensive responsibilities,⁷ Parsons had a hand in all the RTC's major decisions, and was often its able and articulate spokesman. On this occasion, as was customary with "reform" experts like himself,⁸ he saw to it that all of New York's newspapers and many of its important journals published articles or printed long excerpts from his report. This resulted in the Commission receiving considerable publicity of a positive sort, which doubtless affected the referendum vote. The Times, Tribune, World, Commercial and Financial Chronicle, and Record and Guide, were all impressed by the thoroughness of the report and its easily comprehensible conclusions, which the Times neatly distilled in the following formula: "electricity, and as near the surface as practicable."⁹

The favorable reception accorded Parsons' report indicates that the problems which the Commission would confront in implementing the rapid transit decision, had nothing whatsoever to do with technological matters. There was nothing startling or, by this time, particularly innovative about Parsons' conclusions. Though Frank Sprague, the great pioneer in electric traction, had not yet perfected his multiple-unit system of control for individually power cars, an invention which would dispense with heavy locomotives and allow for greater speeds on both elevated and underground railways,¹⁰ electricity was nonetheless a safe bet for the projected underground road, and had already been tried successfully in the City and South London subway, and on elevated lines in Chicago and Liverpool.¹¹ Similarly, Parsons' preference for shallow tunnels had been well established by the RTC of 1891, and his report merely confirmed and provided European illustrations to support its conclusions.

Things took a different and far more controversial turn, however, when in December 1894 Parsons presented a second report to the Commission, in which he touched upon the question of the route and cost of the proposed subway. Briefly stated, he argued that a route constructed under lower Broadway might "exceed the stipulated cost of \$50,000,000 by at least \$15,000,000," and that, consequently, another route under Elm Street (now

Lafayette Street), which was then being "improved," should be chosen.¹² Cost was not, however, Parsons' sole consideration. He was also worried about possible hindrance from Broadway property owners, whose objections he summarily anticipated:

Broadway is, at present, the only thoroughfare in the lower part of the city. It is lined with expensive buildings and its traffic at all times is very heavy. These conditions will inflict an increased cost on the construction of a railway, and the crowding of the work of building the latter in an already congested street must interfere with its regular business.¹³

Parsons' report acted as a catalyst which brought divisions within the Commission itself out into the open. Starin and Inman, who had served on the previous RTC, were all for retaining its proposed route; Low was exceedingly high-minded and wanted only what was "best for the city"; Orr and the other members of the Board took no public position.¹⁴ But since everyone desired to remain within the cost restrictions of the Act, and since no agreement between the Commissioners themselves seemed possible, it was decided to refer the matter to a special Board of Engineering Experts, composed of Abram Hewitt, Octave Chanute of the ASCE panel of 1874-5, rapid transit expert Thomas Curtis Clarke,¹⁵ engineer Charles SooySmith, a close friend of Parsons,¹⁶ and Professor William Burr of the Columbia University School of Engineering. This was the RTC's first great mistake.

The Board of Engineering Experts did not close the can of worms opened by Parsons' report. Rather, it created new divisions and disagreements, and led to a publicly aired controversy which, as Abram Hewitt would correctly observe, "disturbed confidence" in the Commission and "very much impaired" its usefulness.¹⁷ More important yet, the dispute over routes played directly into the hands of Broadway property owners, who were provided with ready-made and "expert" arguments to serve their purpose. And an apparently gratuitous recommendation of the Board of Experts for extensions of the elevated roads questioned the very purpose for which the RTC had been established -- publicly funded construction of an underground railroad.

The Board of Experts agreed with Parsons' preference for Elm Street over Broadway on account of the latter route's cost and inconvenience. In a letter to Benjamin Henning, Hewitt revealed another reason for his Board's position. He did not believe that a Broadway route could "be such as to invite investment of capital," and he doubted that the RTC would find any bidder daring enough to risk dealing with Broadway property owners.¹⁸ It was understood that an Elm Street route would involve considerable delay because "improvement" of the street was not yet complete, and there would be new litigation and objections raised by property owners there as well.¹⁹ But Hewitt and the Board of Experts thought that Elm Street was in the long run a safer bet for the proposed subway than lower Broadway, and that while the Commission waited

for the legal difficulties involving Elm Street to be cleared up, it could use its mandate and the threat of underground construction to force the Manhattan Railway Company to extend its lines and add a third track for express trains.

On this last point The Board of Experts was clearly influenced by Hewitt, whose "strategy" it adopted. The old Mayor was of course not opposed to the idea of a municipally funded subway, but in first proposing the plan, he never intended that the principle of public ownership or the underground road itself should stand in the way of improvements in existing modes of transit. Indeed, his hope and expectation was that the principle of public ownership would give rapid transit advocates a trump card in dealing with private capital generally and with the established transit monopolies in particular. In 1895, with a depression in full swing and with the problem of routes as intractable as ever, he saw little chance for underground construction. The only alternative was to use the threat of underground construction to force concessions from the Manhattan Company. In order to this, however, the Commission would have to interpret its mandate flexibly, which the letter of the Act of 1894 allowed but which the spirit of the referendum vote did not.

The Act of 1894 empowered the Commission to negotiate with existing transit agencies, and Hewitt wanted it to use this power to secure immediate rapid transit relief. In reply to an article in the Times which had pointed out that the Commission could not force the Manhattan Company to add express tracks and extend its lines, Hewitt obliged the paper to publish a letter, first sent to the RTC, which it had "feebly attempted to suppress."²⁰

In reference to your statement that the Rapid Transit Commission has no authority or power to compel the Manhattan Company to make the required improvements, I venture to suggest that it is scarcely necessary to discuss the point until after the negotiation with the Manhattan Company shall have been concluded and failed to produce results. I have every reason to believe that the Manhattan Company will meet the Commission half way in any intelligent effort to afford immediate relief to the congestion of travel. But if it shall turn out to be otherwise, I am assured by competent legal authority that while the Commission has . . . no power to enforce compliance with its wishes, the public authorities of this State have the power to compel a corporation chartered to furnish rapid transit to comply with its obligations whenever the requisite authority shall have been conferred upon it by the Rapid Transit Commission. Certainly no corporation will be permitted in this State and in this age to block the wheels of progress, and there are very few managers of railway enterprises, who are so stupid as not to desire to meet the public's requirements as far as the means at their command will permit.²¹

There was, of course, a great deal that Hewitt did not know about the "means at the command" of the Manhattan Company. But his point was that the Commission had nothing to lose and everything to gain by negotiating with the management of the elevated roads, and, at the very least, should all else prove futile, calling its bluff.

Some members of the Commission, particularly Seth Low, thought differently. In agreeing to serve on the RTC, the President of Columbia College had expressed his belief in public ownership, on the grounds that "under no other condition is a system likely to be devised and built with a large look ahead in the interest of the city, for private capital is almost certain to select the system which will be most immediately profitable, and it may easily be that such a system may not be best for the city."²² Low now took the position that the RTC had been established and the people of New York had voted to confirm its powers for the sole purpose of building a publicly funded subway. Whether the RTC was successful or whether it failed to accomplish this task, in either case its duty was to make the attempt as quickly as possible, at which time its mandate would expire and its work, for better or worse, would be done. Accordingly, Low pressed the Commission to reject the recommendations of the Board of Experts, to drop consideration of the Elm Street route because of the potential delay involved, and to vote on a resolution confirming the route under lower Broadway "already adopted."²³

In the 1902 Commission report to the Mayor, who by an ironic coincidence was none other than Seth Low, there is no reference to this dispute and scant mention of the role of the Board of Engineering Experts. Yet it was this dispute which led to the Commission's first great crisis, which prompted Seth Low's resignation from the RTC in June 1896, and which nearly destroyed the Commission itself, and with it any prospect of a subway in the near future.

In February 1895 the Commission accepted Low's resolution and opted for routes and a plan of construction almost identical to those selected by the RTC of 1891, except that the new routes did not reach the northern limits of the city on the West Side nor go as far into the Bronx on the East Side.²⁴ By state law consent from land-holders owning at least one-half the value of abutting property was once again required, and this, as might be expected, was not forthcoming from real-estate interests along lower Broadway.²⁵ In September 1895 the Commission was thus obliged to appeal to the Supreme Court to secure the consent withheld by the property owners. After first refusing to hear the case, and after being directed to do so by the Court of Appeals, the Supreme Court appointed three commissioners -- Frederic Coudert, William Gelshenee, and George Sherman -- to assess the project's suitability and determine whether it should be constructed. After long and conflicting testimony from Parsons and other experts, some of whom were hired by Broadway landholders and some of whom clearly served the interests of the transit monopolies,²⁶ the Court's Commissioners decided in March 1896 in favor of the RTC.

However in May 1896 the Appellate Division of the Supreme Court rejected the report of its own commissioners. Coudert, Gelshenen, and Sherman were neither rapid transit experts nor engineers. They had not undertaken an independent study, but had relied on the research of Parsons and the RTC, plus what they might learn from the conflicting testimony offered them in public hearings. They were consequently unwilling and unable to give the Court a precise figure regarding the cost of the projected underground railway. In the view of the Court this uncertainty argued against the RTC's routes and plans, and rendered the entire project invalid. The justices also raised objections that would come up again: first, and most important, that the subway's cost would exceed and exhaust the city's debt limit of ten percent on the assessed value of property; and that the projected routes failed to meet the needs of the city, since they did not extend to its northern limits on either the East or West sides.²⁷ As the RTC and everyone else was quick to see, with this judgment the Supreme Court rendered worthless two years of the Commission's work: "... it seemed plain that the Court would not consent to any route under Broadway, or to the construction of an underground route on any other route unless (1) it extended substantially from one end of the City to the other and (2) it was conclusively shown that the total cost would be much less than \$50,000,000."²⁸

The Supreme Court's decision threw the Commission into a quandary. Seth Low's position on the Board was no longer tenable. As was consistent with his view of the Commission's mandate, and as required by his advocacy of a policy which had led it to disaster, he resigned on June 2, 1896. Other members of the Board considered resigning or disbanding the Commission. John Inman thought that the RTC's usefulness had been exhausted, Edward Shepard said that an underground road would never be built, because the court wanted an inexpensive road and at the same time one which extended to the northern limits of the city. Parsons, who considered the subway his "life's work,"²⁹ was despondent. Orr alone held on to the hope that the Commission might continue its work by pursuing a policy similar to that proposed by the Board of Experts -- a subway under Elm Street and/or an extension of the elevated roads.³⁰

At this point the Commission was perhaps saved from itself by the force of public opinion. Letters of support came pouring in from labor unions, reformers, and leading businessmen. Lyman Abbott of Outlook and Albert Shaw of The Review of Reviews defended the RTC. Religious Leaders such as Felix Adler and prominent Jewish businessmen like Oscar Strauss and Jacob Schiff, interested as Jewish philanthropists in the importance of rapid transit in alleviating the problem of overcrowding in the lower East Side, urged the Commission not to abandon its work.³⁰ In June 1896 a delegation of working men paid a visit to a meeting of the RTC, where they showed no hesitation in giving Alexander Orr, its President, the benefit of their popular wisdom. Despite Orr's remark that the RTC was "law abiding," they told him that "the working people were surprised to see the Commission

'knocked out' in one round by five judges," and also that "the law cannot be bigger than the will of the People . . . The Constitution is not better than the will of the People. There is no law through which you cannot drive a coach and four . . ."32

Whether or not the Commission was buoyed by this particular expression of the popular will, it was confirmed by public support and did go on with its work, attempting to serve the public in its own fashion. There was a great difference, of course, between the will of the people and the motives and legal restrictions which limited the activity of the RTC. The public wanted a subway regardless of cost. It also wanted a subway built by the city, but was indifferent as to who leased it or under what terms it was leased after it was built. The Record and Guide interviewed a prominent builder who was willing to see the city spend \$100 million if necessary to construct an underground railway, after which, he said, it could lease the road for a dollar and still pay the interest on its bonds from increased tax valuation in areas which the new rapid transit system would help develop.³³ And a labor union spokesman reminded the Commission that the people had confirmed it but for one purpose -- the municipal construction of a subway. This same spokesman, Charles Stoves, failed even to mention the problem of finding a lessee, and the plain implication of his remarks was that if none could be found, the city should go ahead and do the job by itself.³⁴

The RTC was by contrast restricted in its action by the cost ceiling of \$50 million in the Act of 1894, and by its own insistence -- embodied in the Act -- that whoever constructed the subway should also operate it, a provision which considerably narrowed the field of potential bidders for the contract. Uppermost in Alexander Orr's mind, for example, was the problem of finding "a lessee whose responsibility is beyond peradventure, and who will save the city from all chance of failure."³⁵ To put this another way, it may be said that the RTC was limited by its own perception of economic and political possibility. Its excessive fear of Tammany, and its equally excessive respect for conservative business practice, prevented it from imagining, much less undertaking, any bold initiative.

In the two years since its institution, the RTC had done everything it could to attract the substantial capitalist that it required if the subway, once built, would be run responsibly and efficiently by private enterprise and free from Tammany control. It had opted for a Broadway route, assuming that this route would offer greater profit incentive to the prospective operator. It had also managed to have the Legislature amend the Act of 1894 so that, at a cost to the city of an additional \$5 million, the city rather than the operator would concern itself with payments to abutting property holders.³⁶ Private capital, however, had not been tempted. No one of any means had appeared before the Commission ready to undertake both construction and operation of the road. Difficulties with Broadway property owners, followed by the recent interference from the courts, of course deterred interested parties. Reluctance on the part of a potential bidder

to enter into competition with the established transit monopolies was doubtless also a factor. And if, as the Supreme Court believed, the Broadway route was too expensive for the city, it was likewise too expensive for a prospective bidder. The greater the cost of construction, the higher the annual fee paid by the operator, which perhaps explains why, even before the Supreme Court had overruled the Broadway route, there were no substantial bidders for the contract.

Two contracting firms, Ryan and McDonald of Baltimore and Drake and Stratton of New York, had come before the Commission, but had been immediately disqualified because neither was in position to operate the subway after construction. When John McDonald, contractor for the Baltimore Belt Railroad tunnel and the man who would eventually build the IRT, was questioned by the Board in February 1895, "his answers seemed to give much satisfaction until he said that his parties, although willing to build the road for less than fifty million, did not care to have anything to do with operation."³⁷

Given its own special requirements, and after the blow dealt it by the Supreme Court, there was no other alternative for the RTC but to acknowledge the failure of its earlier policy, and belatedly accept the recommendations of Abram Hewitt and the Board of Engineering Experts. With Seth Low gone, it was now free to pursue the old Mayor's "strategy" wherever it might lead, and it is hardly coincidental that he was its first choice to succeed Low on the Board.³⁸ For a year and a half Hewitt had been a thorn in the Commission's side. He had released a controversial letter to the Times,³⁹ and he had testified against the RTC before the Supreme Court commissioners. Yet now all was forgiven and forgotten, and he was wooed like a reluctant maiden, a role that he appeared to relish. He refused Low's seat, pleading ill health and preoccupation with his declining business affairs and his work at Cooper Union.⁴⁰ Upon John Inman's death early in November 1896, he was once again approached to accept a seat on the Commission, and once again refused. When William Steinway died at the end of November 1896, he gave careful thought to yet another offer, but finally decided against it, recommending Charles Stewart Smith,⁴¹ his old friend and past President of the Chamber of Commerce. Smith was quickly appointed, even though reformers like Albert Shaw, R. Fulton Cutting, and Felix Adler, and a prominent businessman like Jacob Schiff, preferred another candidate, Charles Stover, the rapid transit expert of the trade unions.⁴² In other words, though Hewitt chose not to serve, he nevertheless led, and it was his "strategy" that now determined the policy of the Commission.

The first move in the game was to chart a new route for the projected subway, the cost and extent of which would satisfy the Appellate Division of the Supreme Court. To accomplish this, the RTC sacrificed the public's need and desire for a comprehensive rapid transit system along the lines laid down by the Senate Committee of 1866 and the Commission of 1891. From

the point of view of hindsight, this was a grave error which would take New York almost twenty years to rectify.⁴³ From the Commission's vantage point in 1896 it was a simple and correct decision necessitated by existing circumstances. The courts had rejected, the city debt limit could not bear, and private capital would not bid for a more ambitious subway project. It would take time and more active public effort, broader acceptance of the new philosophy of public responsibility for public works, and clear evidence of the profitability of underground travel, to change these circumstances.

In 1896, then, the route selected was a "trunk line," starting at City Hall and running under Elm Street and Fourth Avenue to 42nd Street, where it crossed to the West Side and ran under Broadway and the Boulevard to Kingsbridge, and with an East Side branch beginning at the Boulevard and 103rd Street and crossing east and running under Lenox Avenue, and then across the Harlem River to Bronx Park.⁴⁴ The cost of the projected road, which extended in zig-zag fashion nearly to the city limits on both the West and East sides, was estimated at between \$30 and \$35 million.⁴⁵

Since property holders on Elm Street of course refused to give their consent to this new route, the Appellate Division of the Supreme Court was, as expected, again asked to approve the RTC's plan. In July 1897 the Court appointed three new commissioners, Arthur Williams, John Sabine Smith, and George Young. This time the Court's commissioners made a careful and independent study. They traveled to Boston to inspect its tiny new subway, and while hesitating to compare this small undertaking with the enormous venture proposed for New York, they were impressed with its dry and well-ventilated tunnels, with its salutary effect on traffic congestion in downtown Boston, and its fair profit return.⁴⁶ In November 1897 they approved both the routes and the cost estimate that the RTC had submitted. In setting forth their decision, Williams, Smith, and Young recognized the necessity for improved rapid transit in a city where increased traffic at an annual rate of twenty million passengers had long overwhelmed the capacity of existing modes of mass transportation.⁴⁷ In December 1897 the Supreme Court assented to this judgment by accepting the report of its commissioners, and by approving the plans and routes of the Commission.

The Court made one further attempt, however, to interfere with the RTC's work. The conservative and cautious justices argued that the contract for so vast and costly an enterprise should be secured by a sum greater than \$1,000,000 bond, and the line on the contractor's equipment stipulated in the Act of 1894.⁴⁸ The Court accordingly fixed a bond of \$15 million, to run the entire duration of the contract. Two months later, at the request of the RTC, it modified its action by requiring one million in security for full term, and fourteen million during construction.⁴⁹ At the end of 1899 the Court would reduce this construction bond further still, to five million, but this relief came far too late to save the Commission from the trials of the next two years.

The Supreme Court's fifteen million dollar bond virtually destroyed Abram Hewitt's and the Commission's "strategy." Hewitt's game plan depended on two conditions: the real possibility of attracting a number of responsible bidders for subway construction and operation, and/or the threat of the same to oblige the Manhattan Company to provide more immediate relief, either in the interest of forestalling competition from a subway for a few years more, or merely to make itself competitive should a subway be built. The effectiveness of this strategy, however, was severely weakened by the \$15 million bond, which acted to deter any new source of capital, that might have ventured \$1,000,000 plus the cost of equipment, but which would not venture, with double sureties,⁵⁰ what the Times estimated as \$39 million in initial capital investment for an undertaking that many still considered risky and which, in addition, was likely to incur the hostility of the two existing transit monopolies.

This situation allowed the two transit monopolies to control the situation, to hold the trump card which, according to Hewitt's plan, was to have been the sole property of the RTC. The large bond assured the Manhattan Company that it was unlikely to encounter competition from an independent source, and that the only other company willing and capable of bidding for the subway contract would be the Metropolitan surface railway, which, like itself, was less interested in the deal that it might make with the RTC, than in the deal it could prevent the RTC making with some third party.

To be sure, the RTC tried to worm out of the box that it found itself in. It sounded out Chauncey Depew and Cornelius Vanderbilt of the New York Central, and Charles Clark of the New Haven and Hartford,⁵¹ but these conversations proved fruitless. This left the Commission with a strategy that had backfired, and with only the two transit monopolies in control of the game.

The Manhattan was perfectly willing to extend its lines and to increase its express service, but at its own pace and in line with its notions of where and when such improvements would be most profitable. As the Times pointed out,⁵² merely electrifying its existing lines would cost almost more than it could afford while still paying a decent dividend, and a thorough-going renovation of its system such as the Commission wanted, was out of the question in the near future.

The Metropolitan would make two offers: one in January 1898, right after the Supreme Court had fixed the \$15 million bond for the duration of the contract, and before it had modified this security to \$14 million for the term of construction; and again in March 1899, when the Commission and the city had problems with the debt limit. The second offer, about which more will be said below, signified the demise of the principle of public ownership, and was one turn of the screw too many for the public, if not the Commission,

to bear. The Metropolitan's first offer provides a good example of the kind of tactics employed by the transit monopolies. In making this offer, William C. Whitney, Thomas F. Ryan, and John D. Crimmins were at pains to emphasize that the \$15 million bond was for their company "a matter of secondary importance," so long as "the enterprise is or can be made profitable."⁵³ The Times showed perspicacity in seeing this as an attempt by the surface railway

. . . to strengthen the decision of the Appellate Court to exact the bond despite any argument which counsel for the Rapid Transit Commission may submit for a modification of the terms. If the Court's order to that effect is entered under present conditions, the Metropolitan people will control the situation absolutely. If it is definitely announced that no one else can give the required bond, and after such an order is entered, that company . . . may, if so disposed, kill the project by declaring "the enterprise cannot be made profitable."⁵⁴

In addition, the RTC's negotiations with the Manhattan and the Metropolitan were made all the more difficult and unprofitable because of the new political and fiscal context in which, as of January 1, 1898, they had to be conducted. The preceeding November the Tammany Candidate, Robert Van Wyck, had won a large victory over the Reform party's Seth Low, who had not received -- as had William Strong in 1894 -- Republican support.⁵⁵ This was an unexpected defeat for the "Mugwumps" -- County Democrats and Independent Republicans alike, and patrician reformers all -- many of whom either sat on the RTC or were associated with its sponsor, the Chamber of Commerce. The new Tammany Mayor's inauguration was simultaneous with another event with unfortunate consequences for the Commission -- the consolidation of Greater New York, joining Manhattan to its suburbs in Brooklyn, Long Island, and Staten Island.⁵⁶ Consolidation ended the old problem of suburban exodus. But in annexing more than ninety previously separate governmental units, the new metropolis was also obliged to assume their debts. This led to great uncertainty about the condition of the city's debt limit of ten percent on the assessed value of property. Until new estimates of the city's enlarged tax base were made, the realization of a municipally constructed subway was indefinitely postponed.⁵⁷

Historians of the subway decision tend to connect the question of the debt limit to Tammany's return to power, choosing to see it as an issue that machine politicians trumped up and exploited in order to hinder the Commission's work.⁵⁸ But this is a false connection deriving from the same source as the view which describes the RTC of 1891 as a "Tammany Commission," and which holds Tammany responsible for the multitudinous problems of the RTC of 1894.

In resisting the temptation to make Tammany a scapegoat, one does not, of course, imply that it was blameless. But it would be equally mistaken to accept uncritically the point of view of some patrician reformers and some members of the RTC, who saw themselves as champions of decency and the public good, and Tammany politicians as wholly corrupt and indifferent to anything but petty graft, payroll padding, and favoritism.

Despite the public image of non-partisanship that the patrician reformers cultivated, they were not "above politics." Indeed, they constituted a political faction, or a number of factions, opposed to Tammany, and in the 1880's, 1890's, and early 1900's, they were often successful in their attempts to remove machine politicians from office.⁵⁹ Even when out of office, through civic organizations, control of or influence with newspapers and journals, and as part of the city's business, professional, and cultural establishment, they exercised a great deal of power, and had their say and some effect on a large variety of municipal decisions. Men like Abram Hewitt, Alexander Orr, Edward Shepard, Seth Low, George Peabody, John Inman, John Starin, Charles Stewart Smith, and many others associated both with "reform" and the Chamber of Commerce, were real political leaders. They had their own well-oiled machines; they were highly conscious of political patronage; and in some cases were personally ambitious for political office.⁶⁰

These patrician reformers were men of greater integrity than the machine politicians, and at least some of them were more concerned with the solution of large substantive public issues than with matters relating to political patronage. The one, however, was not possible without the other: as one troubled associate wrote to Edward Shepard, "Realizing that the leader of a Machine always become a 'boss,' I again say I admire your pluck while I deplore your methods."⁶¹ By contrast, there is no question that a man such as Richard Croker accorded a very high priority to political patronage. But in the last two decades of the nineteenth century even Tammany bosses concerned with private favors to party regulars and individual voters, could not afford to ignore questions of public policy affecting the larger electorate. The old view that "regular" party politicians were indifferent to substantive issues can no longer be sustained. Their survival depended on their taking an interest in policy, and in an era in which reform was fast becoming a watchword, even such an organization as Tammany had to accept it as a reality.⁶²

The division between the patrician reformers and Tammany, then, had less to do with "good" versus "corrupt" government, than with power and political patronage, with the question of who would direct and control decisions on important public issues. The problem was that both groups reacted negatively to the authority of the other. The reformers were hostile and suspicious of decisions controlled by Tammany; machine politicians often opposed certain decisions merely because reform leaders were in charge of the their implementation.

The rapid transit subway decision is a case in point. It will be remembered that the Chamber of Commerce sponsored Act of 1894 was specifically designed not to exclude city officials from participation in the rapid transit decision, but to insure that they had little control over it. When Tammany returned to power in 1898, it was therefore determined to rid itself of a Commission over which it had scant authority and from which it could not expect political patronage. Mayor Van Wyck directed his cabinet officers to have nothing to do with the RTC,⁶³ and Boss Croker was particularly candid in expressing his views and purposes.

As to what the Rapid Transit Board will do, I have but slight notion. I am not in the board's confidence. Moreover, I have but little respect for it. In all the years of its existence it has done nothing but talk, talk, talk. Five bluejays could have done as much. The people have repudiated it at the polls; it has done nothing but talk and waste time and money. . . . The sooner it gets out the better for the public and the better for its own self-respect.⁶⁴

In March 1898 Croker made his one and only positive move to depose the Commission. He and state Republican boss, Thomas Platt, agreed on a bill, sponsored by Senator Ellsworth, abolishing the existing RTC and replacing it with a "bipartisan" board composed of an equal number of "regular" party Democrats and Republicans.⁶⁵

Public reaction to this bill, however, was overwhelmingly unfavorable. Abram Hewitt and the Chamber of Commerce did a good job of raising the moribund spectre of Tweedism, convincing the public that Tammany had only one motive in sponsoring the bill, which was the desire "to lay the hand of spoliation upon the public funds: and "secure the control of every dollar of the public property which can . . . come under their supervision."⁶⁶ Hewitt, who presided over a citizen's Committee of Fifty organized to fight the bill in Albany, spoke of the members of the present Commission as "men who have no superiors in this community or in any other, . . . men who have no personal motives to serve, who have nothing but a desire to do their duty to the community," while describing the RTC of 1891 as a "Tammany Commission" which had done nothing for rapid transit in its three years in office.⁶⁷ And John Harsen Rhoades, in a speech before the Chamber of Commerce that was published verbatim in the reform-oriented Times, said that

Tammany Hall did all it could to defeat rapid transit when it was in power, and now, when its efforts seem to fail, it seeks to remove an honest Commission in order that it may thus either bury rapid transit for years to come or put it under the control of an obedient Commission Let the Community understand that the powers conferred by law upon the Board are unprecedented in their extent, and, if lodged in the hands of dishonest or incapable men, the possibilities of fraud and blackmail and injury to the City would be a constant menace.⁶⁸

Many reformers also thought Tammany deliberately made an issue of the debt limit in order to delay subway construction. The RTC report of 1902, written by Edward Shepard, emphasized the fact that Corporation Counsel John Whalen had held up approval of the contract for the subway for eighteen months from April 1898 to September 1899, with the result that "construction of the railroad was thereby brought to a standstill."⁶⁹ Whalen excused his action by saying that he saw no reason to approve the contract, since uncertainty about the debt limit prevented rapid transit construction and rendered the contract illegal. Shepard refused of course to believe this, and wrote Alexander Orr early in May 1899, suggesting that the RTC make a great public fuss and go to the Legislature about the long delay.

On the very same day -- May 19, 1899⁷⁰ -- that the RTC sent a letter to the Mayor inquiring about the delay, Orr replied in a surprising manner to Shepard's letter. Coming as it did from so partisan a source, and at this particular time in the Commission's history, Orr's letter provides telling evidence to show that Tammany did not invent the problem of the debt limit, and that its fiscal conservatism was shared by eminently respectable businessmen such as the President of the RTC. "I do not believe," Orr told Shepard,

. . . that at any time since the present Administration took office, that they have been in a position to act in the line of rapid transit construction . . . there has not been a day since they took office, that they could have authorized the issue of a single bond for rapid transit purposes, nor would there have been a single buyer for such a bond had they issued them.

Orr also warned Shepard "not to create more antagonism than there is between the RTC and Tammany officials, because he believed that Bird Coler,⁷¹ the Comptroller, was on the Commission's side, and that Mayor Van Wyck was "at least half won over." And he excused the delay of Corporation Counsel Whalen by saying that "I have not felt like blaming the Corporation Counsel severely for retaining the contract, for he knew as well as we did that we could not act, and as far as I know, we did not for a year past insist on his acting on the contract."⁷²

Had Tammany merely trumped up the debt limit issue, or, more precisely, had it dared to exploit a fiscal problem which the capable businessmen of the RTC could easily show to be false, it stood to lose a great deal, particularly since Mayor Van Wyck had been elected on a platform calling for municipal rapid transit construction. The question of the debt limit was in fact real, at least from the standpoint of the overly prudential fiscal practice of the time.

In January 1898 Comptroller Coler estimated that the city was \$13.5 million in excess of its debt limit of ten percent of assessed value of property. The annual revenue from the city's sinking funds was about \$12 million yearly, but even this, if Coler's figures were right, was not enough to build schools, and other necessary public works such as two bridges over the East River connecting Brooklyn and Queens to Manhattan, and still issue bonds for underground railway construction. Since there was some question as to the validity of the debts incurred by the annexed territories for which the greater city was now responsible, and since the assessed value of property in these territories had been calculated at a different rate from New York's, it took a considerable time for the entire matter to move through the courts, and to refigure on a uniform rate the actual status of the debt for which the city was liable. By the spring of 1899, however, this re-evaluation was complete, and it was shown that the city had \$42 million above the debt limit against which bonds could be issued. And when Comptroller Coler relieved this situation even further by approving the RTC's alternative of building the \$35 million subway in segments costing \$10 million yearly, any fiscal obstacle to subway construction was removed.⁷³

But again, as with the Supreme Court's \$15 million security, resolution of the debt limit question came too late, or at least long after the Commission had voluntarily offered to sell its soul to the devil -- that is, had entered into negotiations with both the Manhattan and Metropolitan, which, if successful, would have definitively closed the door on a publicly funded subway.

After the failure of the Ellsworth Bill, Tammany's role was passive; it aided the transit monopolies by standing by while the Manhattan and the Metropolitan actively pursued their interests. Boss Croker was of course not displeased to see his enemies on the Commission⁷⁴ victimized by the two companies, especially since George Gould and William C. Whitney were reportedly large donors to "regular" organization campaign funds.⁷⁵ But the policy of the transit monopolies served Croker's purpose only insofar as it discredited the Commission. Tammany had nothing to gain and much to lose from a policy which sought to delay underground construction indefinitely or to provide improved rapid transit on terms wholly suited to the needs of the monopolies rather than those of the city.

The Manhattan had been actively engaged in blocking the Commission's work since December 1895, when a suit challenging the constitutionality of the Act of 1894 was brought against the Commission by the New York Sun, the one newspaper in the city that always defended the policies of the elevated railway. The Sun claimed that the Act of 1894 provided a loan of municipal funds to a private corporation for a private purpose. After a year and a half of legal battle, the courts upheld the Act and the Commission by defining underground rapid transit as a "city purpose" worthy of public funding.⁷⁶

At about the same time, the Manhattan was busy negotiating with the RTC for extensions, privileges, and surface feeder lines that the Commission had no power to authorize. In June 1896 the company interrupted an RTC busily at work planning the Elm Street route. It requested permission to build extensions of its elevated lines uptown and in the Bronx, to connect these with new surface lines, and to do all of this without compensation to the city and with a Commission guarantee against immunity from claims for damages. The Commission neither could nor would approve this request. It was not empowered to grant extensions free of rent, nor make guarantees against damages, nor assign franchises for surface lines.⁷⁷ The offer was premature, and the situation not ripe for extortion.

Early in 1898, however, after the Supreme Court bond decision and the debt limit question had indefinitely stalled subway construction, the Manhattan was clearly in a better position. The Commission would have gladly accepted any reasonable offer, but the Manhattan did not make such an offer. It asked for connecting lines downtown and extensions uptown on the East and West sides, but was imprecise both with respect to the time it would complete its improvements and its compensation to the city. The RTC, following Hewitt's strategy, called the Manhattan's bluff by proposing seven franchises at rentals of one percent to five percent, subject to readjustment every twenty-five years. The Manhattan need not have accepted all of these franchises, and might have bargained about compensation. It had the tacit support of City Hall, the public was eager for any relief, and the Commission would have been grateful for any show of conciliation. But George Gould would only promise to accept one of the franchises along West Street, and at one-half percent compensation rather than the five percent the RTC had requested. Gould had achieved his principal aim, which was to delay and impede underground construction. The Manhattan was just then beginning to consider electrification of its lines, which, when completed, would suffice to make the Manhattan competitive at least with the surface railways,⁷⁸ and Gould doubtless believed that extensions of his road could be postponed until such time as the RTC had no other alternative than to accept his extortionate terms. After frustrating negotiations which lasted for more than three quarters of a year, the Commission was obliged to admit that in its present circumstances the Hewitt strategy hardly constituted a threat to the Manhattan Company. It therefore ended negotiations with Gould, remarking "that no useful purpose will be served by further delay."⁷⁹

At the end of 1898 the Commission had just about exhausted the resources of its strategy, and was nearly ready to close up shop. William Barclay Parsons left for Hong Kong in order to pursue another large scheme, this time for a Chinese railway,⁸⁰ and wrote Edward Shepard asking that "should the Rapid Transit Commission dissolve" and his subway contract drawings be "ordered to be turned over to the city authorities, . . . try if possible to arrange that the plans can be 'forgotten.'"⁸¹ A few months later, however,

he was encouraged by a reply from Shepard, indicating that rapid transit matters were improving. The Commission's hopes were raised by a new and surprising offer from the Metropolitan Company, which proposed to build the subway with its own capital.

The Metropolitan's initiative was hardly surprising. Since its first offer in January 1898, the company had been patiently waiting on the sidelines, ready to enter the game whenever the Manhattan was ruled out. The Commission, however, was hardly a worthy opponent. It had little time left for games, and for several reasons was quite willing to accept any terms that the Metropolitan might propose. It knew that the debt limit question was not likely to be quickly resolved, and some of its members feared that Tammany would use the issue to stall subway construction until the Commission resigned or was replaced. To save itself both from discredit and extinction, the Commission needed to build a subway, and if municipal construction was eliminated, private construction was the last and not the least desirable resort.

Men like Parsons, Shepard, and Rives had only reluctantly accepted the principle of public ownership, because, as Parsons said, "the need of a rapid transit line is . . . so great, that every personal consideration should give way in order to attain this end." But their personal preference was for construction by private capital, both because they were opposed to "all socialistic tendencies," and also because Tammany's presence argued for "a short step from municipal ownership to municipal operation."⁸²

There was, moreover, good reason to believe that the Metropolitan could "carry out the work better for all interests than any other concern." Its control of the city's most important surface lines, its system of transfers, and its financial, organizational, and technical expertise in traction matters, allowed it to promise quick completion of the first segment of the underground road, and good connections at a reduced fare with its surface railways.⁸³

Negotiations between the RTC and lawyers for the Metropolitan began in January 1899. At the end of March a public proposal was made, specifying the Metropolitan's terms. The surface railway company agreed to build the underground road with private capital and pay the city an annual rental of five percent on the cost of construction, providing that it was granted a perpetual franchise. In addition, it was to be exempt from taxation until the road paid its cost plus five percent, and could reduce the rental fee at any time that the gross receipts failed to pay five percent on the cost of construction beyond operating expenses and taxes. The fare was to be five cents for local service, ten cents for express service, and an additional three cents for transfers to the company's surface lines. As will be seen, perhaps the most important clause in the proposed agreement was the one which allowed the Metropolitan to place electric, telephone, and telegraph conduits in and adjacent to its tunnel.⁸⁴

The Commission's eager acceptance of the Metropolitan proposal signified its willingness to abandon the conditions of the Act by which it was constituted. Orr now described municipal construction as "a distant possibility," and spoke with understanding of the Metropolitan's demand for exemption from taxation and a perpetual franchise. "It strikes me as reasonable," he said, "that those who put up the money to build the road, and who take whatever risks there may be, should first get back interests on their outlay . . . I am rather inclined to think that we shall have to grant perpetual franchise in order to induce capitalists to undertake the building of a rapid transit road with their own money."⁸⁵ As Orr knew only too well, however, the deal was neither legal nor in line with prevailing state or city policy. The Act of 1894 called for public ownership; the Charter of Greater New York restricted sale of franchises to a limited period; a projected state law -- the Special Franchise Tax Act -- then moving through the Legislature, provided that franchises, like real property, be subject to taxation; and the Act, city custom, and popular expectation since 1886 mandated a uniform five-cent fare.⁸⁶ All of this required that the Commission go before the Legislature and request special plenary powers in direct contradiction to its own mandate and, as it turned out, contrary to the will of the people.

Public reaction to the Commission's actions and its formal "Memorial to the Legislature on Construction by Private Capital," was instantaneous, unfavorable, and rather remarkable. Suddenly the rapid transit question was transformed from a decision made by the city's elites into one made by the public and simply ratified by its representatives. The Times reported mass meetings throughout the city for weeks after the Metropolitan proposal was made public.⁸⁷ Almost every civic association, immigrant or ethnic organization, and labor union expressed their opposition to private subway construction. Tammany Boss Croker, the Metropolitan syndicate, and the RTC were all lumped together and denounced. "This is not a question of politics," said Thomas Scanlon of the Central Federated Union, ". . . good citizens of every political opinion are against the outrageous surrender by the Rapid Transit Commission. They cannot understand what Tammany Hall, the dominant and responsible political organization, means. They cannot believe it serious when so soon it attempts what is virtually a breach of faith with the masses from whom it gets its votes."⁸⁸

Not surprisingly, this public outcry created a breach within the ranks of Tammany itself. Boss Croker and his puppet, Mayor Van Wyck, supported the Metropolitan deal.⁸⁹ But the Tammany machine was not the monolith that patrician reformers believed it to be, and a considerable number of "regular" party politicians, mindful of the electorate which had voted them into office, either immediately sided with or soon thereafter ratified the popular will. The Democratic leader of the Senate, several New York City members of the Assembly Committee on Cities, Comptroller Bird Coler, and Louis Haffen, the Tammany Bronx borough president, all made strong public statements opposing the RTC's memorial.⁹⁰

Popular opinion, however, had little effect on the Commission's position, until one of the public's bolder and more forthright representatives took matters into his own hands. On April 18 Governor Theodore Roosevelt solidly declared against giving the Commission power to bestow either a free franchise or a franchise in perpetuity. The Governor invited the Commission to travel to Albany for serious private discussions, the substance of which he, rather gleefully, made public directly afterwards. The RTC insisted that "a fifty year franchise was nonsense, and that nobody would dream of bidding," and that the "city authorities didn't want to construct the road." The hero of San Juan hill responded that delay was a lesser evil than a perpetual franchise, and that the Commission need not worry itself about city officials.

I said that I would not be scared by any bogie of home rule, and that I would cheerfully sign a bill that would compel the city authorities to furnish the means to build the road under the supervision of the present or some other competent Commission.

A year and one half later Theodore Roosevelt would tell Henry Cabot Lodge that it was the New York traction magnates -- "the big corporation men of the William C. Whitney, Thomas Ryan, Anthony N. Brady stripe" -- who had been responsible for his leaving the Governor's office and being kicked upstairs to the Vice-Presidency.⁹² If true, there is no doubt that his interference in the rapid transit decision, as well as his support for the Special Franchise Tax Act, helped to earn him the enmity of these men.

Whitney and Ryan of the Metropolitan and Brady, the promoter behind the Brooklyn Rapid Transit Company, which held a monopoly of elevated and street car lines in that borough, were probably less bothered by the Metropolitan's having lost its opportunity to build a subway, than by the fact that, with the loss of the subway, all three men also had to relinquish their plans for monopolistic control of New York's utility industry. Whitney, Ryan, Brady, and the two ubiquitous Philadelphians, Elkins and Widener, were involved in utilities such as electric light and gas, as well as in street railways. In 1898 all of these men had formed a mammoth holding company, the New York Gas and Electric Light, Heat, and Power Company.⁹³ As they would admit after the defeat of the Metropolitan proposal for private subway construction, their principal interest was not the subway itself, which they "at no time . . . regarded . . . as a big money making scheme," but rather "the other revenues from the tunnel," namely the conduits for gas, electricity, telephone, and telegraph.⁹⁴ And it was these same conduits, and not the expectation of vast profits from the subway, that led the usually astute William C. Whitney to misjudge badly both the inclination and power of public opinion regarding the rapid transit question.

With the Metropolitan out of the picture, with Tammany split, with the problem of the debt limit resolved, and with the public's demands loudly and clearly expressed, there was nothing else that the courts, Boss Croker, or

the RTC itself could do to prevent or further delay offering the subway contract to bidders. In September 1899 Corporation Counsel Whalen approved the contract. In October city officials joined the Commission in petitioning the Supreme Court to reduce its construction bond to \$5 million.⁹⁵ The Commission set January 15, 1900 as the date when bids for the contract would be accepted.

The time had come for the rapid transit decision to become a reality. Thanks to the public, two important steps in that direction had already been taken. The transit monopolies had lost their game to preclude municipal construction, and the power of public sentiment had at last united two essential parties to any successful conclusion of the story -- Tammany and the businessmen reformers of the RTC. Together, these two elites would find a third party -- someone with good standing in both camps and a substantial, reputable capitalist to boot -- who would bring the IRT, New York's first subway, into being.

v

In January 1900 everything that had once stood in the way of subway construction had been overcome. Technology was no longer a problem: Frank Sprague had perfected his multiple-unit control system for electric motive power, and tunnel construction was long beyond the innovative stage. Subways in Boston, London, Paris, and Budapest, had demonstrated that underground travel could be as comfortable and attractive as surface or elevated railways.¹ The new subway would still be expensive. But with corollary expenses such as real estate² and abutter's rights³ paid for by the city, and with the municipality offering \$35 million in public funds for an underground railway whose construction cost was estimated at \$26 or \$27 million,⁴ the prospective contractor stood to make a profit on construction that would offset the expense of equipment and rolling stock. The route chosen for the new road was not ideal, but it did eliminate the long-standing obstacle of opposition from powerful property holders along Broadway. Public reaction against offers carrying extortionate terms and delaying tactics, had finally thwarted the transit monopolies' attempts to prevent subway construction; their only remaining opportunity was to bid for the subway themselves. Public need and the clear expression of the popular will had enforced a truce between New York's two belligerent political elites. Patrician reformers and Tammany machine politicians were now united to serve if not to rule. The imagination and expectations of the public were obviously aroused by the prospect of underground travel, a fact which confirmed the Commission's belief that the new subway would be both a popular and profitable venture for any capitalist sufficiently clever and bold to undertake its construction.

But even with these obstacles out of the way, and with the path thus smoothed by the public and government, the subway contract itself was not as attractive to the turn of the century American capitalist as, from

hindsight, one might assume. The project was much less risky than it once had been, but there was still uncertainty about initial profitability, and, just as important, unease with respect to a contract that restricted the freedom of private capital in order to meet the needs of the public.

Few now doubted that the subway would eventually be profitable. The new underground road would encourage and at the same time benefit from what everyone saw as the inevitable growth of America's principal city. But would the new subway's initial earnings assure at least a six or seven percent return⁵ in excess of operating expenses and the annual rental of interest on city bonds plus one percent for the sinking fund? Would heavy short-haul traffic downtown, where the subway would have to compete with the newly electrified elevated railways and surface trolleys, offset what was expected to be an initially sparse long-haul traffic in undeveloped uptown areas?⁶ And would the uniform five-cent fare, stipulated by the Rapid Transit Acts of 1891 and 1894, be enough to cover these contingencies?

Risks and uncertainty of this kind were of course to be expected; entrepreneurial capitalism and a certain amount of risk were synonymous. At the same time, the system of unregulated nineteenth-century capitalism also provided the entrepreneur with the freedom to safeguard himself against such risks. He could slow down or postpone construction, use merely standard rather than superior materials in construction, reduce service, delay innovation and improvement, raise additional capital and dividends and profit by resort to "watered" stock. All or some of these measures had been frequently employed in the construction and operation of the city's surface and elevated railways.

None of these safeguards were available to the prospective contractor and lessee of the new subway. He was not only asked to undertake a large and still unproven venture, but was also required to enter into a new relation with government. The contract was consistent with previous public transit policy regulation by fixed grant. As later criticism would show, there was no provision for an ongoing system of regulation and inspection of service with appropriate and specific penalties short of confiscation. The contract was nevertheless far more detailed, and restricted the lessee's actions more substantially, than earlier and similar fixed charters.

The contract contained one hundred and eighty pages of rules and regulations governing the time, modes, and materials of construction, and the policy to be followed in the road's operation. The subway was to follow the Commission's plans of 1896 for a twenty-one mile "trunk line" route, mostly through tunnel but partly by viaduct, starting at City Hall and running under Elm Street and Fourth Avenue to 42nd Street, where it crossed to the West Side and ran under Broadway and the Boulevard to Kingsbridge, and with an East Side branch beginning at the Boulevard and 103rd Street and crossing east and running under Lenox Avenue, and, and then across the Harlem River to Bronx Park.

The contractor was to commence work on the subway within thirty days of the execution of the contract, and proceed with construction in four stages, all of which were to be completed within four and one-half years. He was liable for delays, and if he went beyond the time limit for completion of the entire project, he was subject to forfeiture of two percent of the unpaid balance for each month in excess of the time allotted.⁸ In case of default in construction, the contractor stood to lose all of the \$5 million construction bond. In building the subway, he was required to rearrange all subsurface structures, repair all streets, and support all buildings affected by construction. He was liable for all damages incurred in the course of construction, and was required to provide a security bond of \$1,000,000 during construction to protect the city. He was also to furnish the equipment of the railroad, including rolling stock, boilers, engines, power houses, real estate for the power houses, tools, machinery for generating and lines for distributing electricity, signalling systems, and ventilation devices, all of which had to be "of the very best known character."⁹ In the event of failure to construct or operate, the city would have first lien on the equipment, and at the expiration of the lease, it would buy the equipment at a price determined by "the condition, wear, and tear of the property."¹⁰

The provisions governing operation were equally stringent. The lessee was required to deposit a security bond of \$1,000,000 for the full term of the lease -- fifty years, with a renewal option of twenty-five years. The minimal annual rental was fixed at a sum equal to the annual interest on the city's construction bonds, plus one percent for a sinking fund.¹¹ The lessee was responsible for running local trains at no less than fourteen miles an hour, and express trains at no less than thirty miles an hour, and was also required to comply with specific rules regarding the number of trains to be run at different intervals for different periods of the day and night. The stations were to be well constructed and decorated with the best materials, and provided with clean and comfortable waiting rooms, washrooms, and toilets. All equipment and stations were to be maintained in good condition, and stations and cars were to be heated, lighted, and adequately ventilated.¹²

For the time, and in light of the potential risks that were thought to be involved, the contract assured a standard of construction and operation far stricter and higher than was customary for public transit owned and run solely by private enterprise. The city was extraordinarily well served by these standards, and in addition was well protected by the financial arrangements of the contract, which stipulated a sum of \$7 million dollars in security, \$6 million of which was to be held by the municipal government until construction was completed, and \$5 million of which was to be guaranteed by double sureties.¹³ In return for these large bonds and for relieving the city of risk in both construction and operation, the lessee of the road was accorded all its potential profits. At the time, however, these were unknown and the terms of the contract as to security bonds and standards of construction and operation appeared unduly onerous. This attitude would alter dramatically

even before construction of the first subway was complete, when it became clear that the road would be profitable, and that real estate development to the north would anticipate rather than merely follow upon its realization. But as the twelve years before 1900 had demonstrated, up until this time the arrangement was not particularly attractive to late nineteenth-century businessmen. Few capitalists were willing or able to bid on the project.

Indeed, on January 15, 1900, the date set by the Commission for receiving bids, no substantial capitalist could be found among the bidders. Only two men presented themselves, and while both were respectable, able, and experienced building contractors, neither fit the Commission's bill. The Rapid Transit Act of 1894 stipulated that the contract was for both construction and operation. By implication the prospective bidder was envisaged as a capitalist of great means and banking connection, with expertise in the financing, organization, and management of large railroad enterprises.

John B. McDonald and Andrew Onderdonk did not meet these requirements. They were hard working construction men of average means, who could be trusted to build the road efficiently and well, but not to run it. McDonald was no stranger to the Commission. He had appeared before it in 1895, with an offer to construct its first route, and had been turned away quite summarily when it was discovered that he had no substantial backing, and that he planned to construct but not to operate the road. He was, it was true, a man of considerable reputation in his field. William Barclay Parsons had spoken highly of his work on the tunnel for the Baltimore Belt Railway,¹⁴ and before Baltimore he had worked on the Boston, Hoosiac Tunnel and Western Railroad, on the extension of the Delaware, Lackawanna and Western Railroad from Binghamton to Buffalo, on the construction of the Potomac Valley Railroad, and he had built a large portion of the West Shore Railroad.¹⁵ In 1895 he returned to New York, where, thanks to Tammany connections,¹⁶ he secured the contract for construction of the Jerome Park Reservoir. Despite his extensive experience in railroad construction, in 1900 as in 1895 his position was very clear. He hoped to build New York's underground railway, but had no desire to run it. "I am a contractor," he told the RTC, "not a railroad man, and I guess I had better stick to my business."¹⁷

Like McDonald, Andrew Onderdonk spent most of his professional life building railroads. He had constructed a section of the Canadian Pacific Railway through British Columbia, had built the railroad tunnel under Lake Michigan at Chicago, and in 1900 was in New York working on a ship channel in the city's harbor.¹⁸

Both men were sufficiently prestigious in their field to deserve the Commission's attention, but neither one should have had the slightest chance to win a contract that was intended for a Morgan, a Vanderbilt, a Whitney, or someone else of their stature in the world of railroad finance and management. Yet the RTC considered these two bids with the utmost seriousness, and on January 16 awarded the contract to McDonald.

Something was clearly afoot behind the scenes. The press was right in believing that the two contractors were acting as surrogates for larger interests, but most newspapers speculated wildly and often incorrectly as to the identity of McDonald's and Onderdonk's silent backers. The Times and several other newspapers at first thought that Onderdonk represented "Vanderbilt interests," and that McDonald, who was Corporation Counsel John Whalen's cousin, represented Tammany and the "Whitney syndicate."¹⁹ The Herald was alone in guessing, probably correctly, that the real candidate of the Whitney-Metropolitan syndicate was Onderdonk.²⁰ A letter from Whitney to the RTC²¹ after McDonald was awarded the contract, tends to confirm this assumption, as does the Metropolitan's almost certain influence in persuading several surety companies to aid Onderdonk's candidacy indirectly by refusing to guarantee McDonald's security bonds.²² Once having given the contract to McDonald, however, the Commission stuck with him, doubtless on the strength of his backer's name and fortune. The identity of McDonald's silent partner was kept a carefully guarded secret for more than two weeks after the contract had been awarded. The press was totally in the dark, and everyone was caught by surprise when, on January 28, 1900, August Belmont II revealed himself as the man behind McDonald.²³

On the one hand, the events of the last two weeks of January 1900 prior to this announcement were and remain clouded in mystery, which accounts for the surprise of both the public and the press. On the other hand, one wonders why no one ever thought of Belmont, for he was so precisely suited to the needs of the RTC and the task of subway construction and operation, that it may be said of him as of Voltaire's God, that had he not existed it would have been necessary to invent him.

What may be described as the standard account of the events of January 1900 was set forth by Belmont himself, and by two participants in these events, Andrew Freedman, who supposedly acted as a go-between for McDonald and Belmont, and by John T. Hettrick, a newspaperman who worked for Belmont.²⁴ As was clear from his interest in subway construction as early as 1895, McDonald wanted to build the road, and knew from his previous experience that he could manage the job. Having received assurances from several surety companies that they would guarantee his bonds, he approached Andrew Freedman, a Tammany associate who was a business partner of Richard Croker, a former manager of the New York Giants baseball team, and also Vice-President and Managing Director of the United States Fidelity and Guaranty Company of Maryland.²⁵ McDonald asked Freedman to help him find \$150,000, which was needed as a deposit for the RTC on the day when bids would be made. Freedman liked the scheme, pledged \$45,000 on his own, and found four other friends - John Pierce, Howard Carroll, C.W. Morse, and H.G. Runkle -- who promised to raise the rest of the money. At 11 A.M. on January 15, however, this loosely organized syndicate still lacked \$50,000 of the required \$150,000, and McDonald had to be at the Commission's offices at noon sharp with cash in hand. Faced with this emergency, Freedman thought of his friend, August Belmont, who, despite his exalted social and financial status, was a solid "regular" organization

Democrat with many Tammany connections.²⁶ Freedman explained McDonald's proposal and his plight to Belmont, who immediately "arranged for the cash, . . . without reading the contract, and without any further talk."²⁷ Subsequently, when the surety companies who had promised McDonald their backing, reneged on their commitment, Belmont organized a construction company, and used his own and his brother Perry's fortune as a source of supply for some of the money that was required as security. By this time, of course, the RTC was in on the secret, since it, together with Belmont, petitioned the Supreme Court to rescind its order that the \$5 million construction bond be guaranteed by double sureties.²⁸ It seems that once Belmont had gambled on McDonald's bid, he was ready to take on any and all powerful interests, including the Whitney syndicate, which threatened its success. "From that moment," said Andrew Freedman, "his life and soul was in the enterprise."²⁹

This is a wonderful story, one that deserves to be part of the folklore of American Capitalism, but it lacks plausibility. First, it is difficult to understand how McDonald could have appeared before the Commission without backing from someone in position to operate the subway once he had built it. It tests one's credulity to be asked to believe that the Board would accept an offer in 1900 that it had rejected in 1895. And it is also curious that a financier of Belmont's shrewdness and circumspection should give Andrew Freedman \$50,000 on short notice, and "without reading the contract" or "further talk."

Additional information about August Belmont adds somewhat to the story's plausibility. It can at least be said that Belmont was especially well prepared to make so quick a decision involving great risk of money, effort, and reputation. This was not his first experience with subway schemes, and he was well-acquainted with all the parties to this particular scheme. In the late 1880's he and William Barclay Parsons had promoted the New York District Railway Company, and according to Belmont's grandson it was not Freedman but Parsons, who was responsible for the financier's decision to commit himself to the creation of New York's first subway.³⁰ Belmont and Parsons were close friends, and the former was often drawn into the latter's adventurous schemes. Their relation before, during, and after the construction of the subway was that of two business partners, with Parsons as the partner who initiated the plans for great projects, and Belmont as the partner whose money and financial acumen brought the project to realization. Parsons was the inspiration for Belmont's participation in the New York District Railway scheme, in the Chinese Railway,³¹ and, later, in the construction of the Cape Cod Canal,³² and it is not implausible to assume that it was Parsons who also interested him in the subway.

Or perhaps it was John McDonald himself who brought Belmont into the venture. Perry Belmont would claim the credit for introducing the contractor to his brother,³³ after having become acquainted with McDonald through Tammany, and fired up about "his plans for the construction of a subway on Manhattan Island." Knowing McDonald as he did, it is a little easier to see why Belmont would advance Freedman \$50,000 on the spot, so that the contractor could make his bid. At the same time, once it is clear that the two men were well-acquainted with each other, one is tempted to ask why either Freedman or McDonald would have waited until the very last

moment to go to Belmont, or why Belmont, on his part, did not suggest his interest in subway construction to McDonald.³⁴

Of course Belmont did not require either Parsons or McDonald to interest him in railroad or urban transit enterprises. His father, the first August Belmont, had founded the Louisville and Nashville Railroad, and since his father's death in 1890, he had managed this prosperous and expanding road. The Louisville and Nashville not only enhanced the family's fortunes, but also allowed Belmont entry into the charmed circle of great railroad financiers; he had business and social ties with such men as E.H. Harriman of the Union Pacific, Stuyvesant Fish of the Illinois Central, and H.H. Porter of the Rock Island railroad system.³⁵ Together with several other financiers and big railroad men, he was also part of the syndicate that had assumed control of the Long Island Railroad after Austin Cobbin's death in 1896,³⁶ and on his own he had bought into and expanded several surface railways in Queens. Only a year before he entered into the subway venture, he was occupied with urban rapid transit in Brooklyn, where, together with General James Jourdan and Walter Oakman, both of whom would later serve as directors of the IRT, he bought the Brooklyn and Brighton Beach and Kings County Elevated Railroad systems.³⁷ Within a few months, these two roads were merged into the vast surface and elevated railway monopoly of the Brooklyn Rapid Transit Company, controlled by Anthony Brady and former Governor Anson Flower, and Belmont was rewarded with a huge profit and a seat on the Board of the Directors of the B.R.T.³⁸

He came out of Brooklyn with a great deal of money -- \$2,000,000 was the sum cited in the Times³⁹ -- but with no transit empire of his own. In the sporting world of New York's elite, Belmont was an avid competitor on par with such men as J.P. Morgan and William C. Whitney. But he was not as yet the equal of these same men in the business world. Morgan, Vanderbilt, Harriman, and Fish were the great names in inter-urban railways; the Pratts, Brady, Whitney, Ryan, Gould, and Sage controlled New York's transit industry. It is not presuming too much to suppose that August Belmont saw in the subway an opportunity not only to make a great deal of money, but also to create for himself a transit empire equal to and perhaps surpassing the empires of those men who were his natural peers and competitors. He had the means, the financial skill, the management experience, and, with his Democratic and Tammany connections, even the political clout to undertake the project. Andrew Freedman doubtless knew all of this when he visited Belmont on January 15. Again, however, one wonders why a man in Belmont's position should have waited until an offer came from Freedman or McDonald, when he might just as easily have taken the initiative and made an offer of his own.

Mention of Belmont's connection with Tammany raises yet another question. His father had been a life-long Democrat, Tammany man, and Chairman of the Democratic National Committee during the Civil War.⁴⁰ Despite their patrician status, both Perry and August Belmont remained good Tammany men and actively

involved in the business of the New York City Democracy at a time when other patricians became "mugwumps" and reformers. Perry served on the Tammany Finance Committee alongside John McDonald and Andrew Freedman, the friend, constant companion, and business partner of Boss Croker. August Belmont knew Croker and, like William C. Whitney, fanned the Tammany politician's vanity by according him full social status as a fellow sportsman, horse-breeder, and racing enthusiast.⁴¹

After the subway was built, the Progressive journalist, Ray Stannard Baker, would characterize the contract as "the subway deal," and claim that Tammany knew beforehand, indeed had seen to Belmont's participation. Everyone connected with the events of January 1900 -- the RTC, Belmont, McDonald, Bird Coler, Andrew Freedman, Parsons -- of course denied Tammany's involvement.⁴² But they protested rather too much. And as the Times noted, all of McDonald's associates in the syndicate formed to raise the \$150,000 deposit were well-known Tammany leaders.⁴³ Having finally committed itself to subway construction and having entered into momentary alliance with the RTC for this purpose, Tammany was doubtless concerned that a suitable candidate be chosen to construct and operate the road. The Times said that McDonald had won Tammany's approval at a secret meeting held ten days before he made his bid.⁴⁴ But McDonald alone would get nowhere with the Commission, and it is difficult to see why Tammany would take the trouble to pick McDonald, while neglecting to line up a potential operator who could stand behind him. Tammany may have had Whitney and the Metropolitan in mind for this role, and of course Whitney and Boss Croker were very good friends. But after the public clamor over the Metropolitan's offer of private construction in return for a perpetual franchise, the surface railway monopoly was not necessarily the best choice. Belmont was better. He was rich, politically "regular," a man who repeatedly did not indulge in the financial chicanery common among his peers,⁴⁵ and, most important, despite his Tammany connections, he was a prominent and active member of the Chamber of Commerce,⁴⁶ and therefore perfectly acceptable to the patrician reformers of the RTC.

On its side, the Commission seems to have made up its mind about McDonald's bid with uncustomary rapidity. On the afternoon of the 15th, directly after the bids were submitted, one of the Commissioners responded to a question about the two bids by implying that the RTC was inclined to favor McDonald's.⁴⁷ On the evening of the 15th, McDonald told the Times that he "expected to get the contract," and was already busy laying plans for the beginning of construction.⁴⁸ Both these statements were made fully two days before the RTC officially announced that McDonald was the successful bidder.

The Board gave two reasons for having selected McDonald over Onderdonk. The former's bid had been \$35,000,000 with no percentage of gross receipts in excess of \$5,000,000. Onderdonk had requested more than this -- \$39,000,000 -- for construction, but had promised the city five percent of the first \$1,000,000 in revenues in excess of \$5,000,000 each year, and two and one-half

percent more on each additional \$1,000,000 of gross receipts up to a maximum of fifteen percent.⁴⁹ The Commission was rather quick to say that "these offers of . . . additional compensation to the city never pan out,"⁵⁰ and to decide that McDonald's lower bid would leave something in the kitty for expansion of the subway in the near future.

In the absence of other evidence, all that can be said of the RTC's decision is that the entire procedure seems to have been preordained, and that Onderdonk never had much of a chance of receiving the contract. On his own, McDonald should have been no more favored than Onderdonk, and if things were as they appeared, neither builder should have been awarded the contract. Yet in a letter of January 16 to Alexander Orr, William C. Whitney described the two bidders as "responsible and capable parties" who would "necessarily complete the work,"⁵¹ a characterization which may merely have referred to their reputation in their trade, but more probably alluded to their silent backers -- Whitney for Onderdonk and, as Whitney probably surmized, someone equally important -- for McDonald. For only with someone like Belmont behind him from the first, and with Tammany and the RTC in on the arrangements, could McDonald confidently say that he "expected to get the contract."⁵²

Belmont, McDonald, and Freedman maintained their story concerning the origins of their partnership during the next twenty years, through civil suits and governmental investigations.⁵³ It was not a very plausible story, but it was certainly very useful. It preserved secrecy that was essential at the beginning of the venture. It protected all the parties concerned, both in 1900 and much later. And after the procedures for awarding "Contract One" came under heavy criticism from Progressives as the "subway deal," it allowed the participants to this deal to deny what was both plausible and very likely true, that Belmont, Tammany, and the RTC had prearranged the entire matter.

Secrecy was very important before the bids were made. Had Belmont let it be known that he was behind McDonald, he risked the ire as well as the interference of Whitney and the Metropolitan interests, not to mention opposition on the part of the Manhattan Company. His air, and the aim of Tammany and the RTC, was to inhibit rather than to call forth competition. Surprise was essential, and it was far better to have everyone believe that, as in 1892, there would be no substantial bidders for the contract, than to stimulate competition by letting everyone know that someone as savvy and well-heeled as August Belmont was interested in the subway project.

The possibility of an adverse public reaction to a prearranged deal between the RTC and Belmont also made secrecy advisable. Part of the reason for the failure of Abram Hewitt's plan in 1888 was that he had openly stated his intention to have Vanderbilt and the New York Central construct and run the railroad, and public sentiment against any "deal" was likely to be stronger in 1900 than it had been in Hewitt's time. The auction of the contract had to be conducted with the appearance of utmost impartiality and fairness, lest

the Commission, which had so spotless a reputation for integrity and honesty, be assailed with the same kind of charge that some of its members or partisans frequently made against Tammany. Nor would it have been particularly good for the Commission's reputation, had it become known that it had not only participated in a deal between Belmont and McDonald, but that it had done so in collusion with Tammany. And later, when Progressive critics were looking for evidence of a deal that they were sure had been made, this same story served to rebut their charges.

What lends credence to the Progressive assumption of a prearranged deal, is the fact that after six years of difficulty, frustration, and near failure, the Commission desperately needed to succeed. The vociferous public demand for a subway also forced Tammany to act decisively and to aid the Commission in every way possible. Tammany had promised the people that subway construction would begin before the end of Van Wyck's term as mayor,⁵⁴ and the public reaction to the Metropolitan's offer of 1899 made it clear that this was one promise that the machine could not afford to forget.

But if, as seems plausible, a deal was prearranged between Belmont, McDonald, and the RTC, it was neither illegal nor extraordinary, given the business practices of the time. It was merely inconsistent with the high moral tone, that quality of being above-the-board and beyond suspicion, that men like Belmont and the members of the Commission strove to maintain, and was also the sort of deal that the public, in its "reformist" frame of mind, might regard with disfavor. Nor, considering his unique capacities for the job, did Belmont expect any benefit from the deal other than what any capitalist of his time had reason to expect, and what both the RTC and Tammany wanted him to have -- large profits, and, in return for his courage in being the first to risk the subway venture, a fair opportunity to create a rapid transit monopoly.

Belmont would come close to achieving these aims, but there would be many unanticipated difficulties along the way. He was confronted with the first such problem at the very beginning of the enterprise. His decision to back McDonald may have been less spontaneous than his or Freedman's story would lead one to believe, but what is undoubtedly true is that he never expected that he would have to support McDonald's bid with a large amount of his own and his brother's money.

McDonald had been led to believe that several bonding companies would provide the money for the required securities, and all that Belmont would have to do was put up the money for the cash deposit, and working capital for construction. As things turned out, however, two of the surety companies -- the Fidelity and Deposit Company and the American Surety Company -- went back on their word, and refused to advance McDonald the money unless "cash or its equivalent representing the full amount of their bond was practically set apart for them," and unless they were paid one percent annually -- \$50,000 -- for the full term of the \$5 million construction bond.⁵⁵

Faced with this difficulty, Belmont at first agreed to provide only the \$1,000,000 bond required by the city as a deposit against damages; this agreement, dated January 20, 1900,⁵⁶ was the first formal one between the two men, and also the first of several by which Belmont bound McDonald hand and foot. The remaining \$6 million -- for the construction and continuing bond -- still had to be secured from other sources such as the surety companies. After a few more days of negotiation, this proved impossible, because Andrew Freedman's company, the United States Fidelity and Guaranty Company, was still ready to honor its promise to McDonald.⁵⁷

The two companies that reneged on their commitment to the contractor were not acting solely on their own initiative. They were under the influence of William C. Whitney and the Metropolitan Railway. It was no secret that several men associated with Whitney and his syndicate sat on the Boards of these firms, and Whitney's biographer has said that the promises made to McDonald were in fact never intended to be kept.⁵⁸ This was Whitney's way of safeguarding himself in the event that McDonald, rather than his candidate, Onderdonk, was awarded the contract. Whitney did not of course know about Belmont, and he assumed that once the bonding companies withdrew their support from McDonald, the RTC would quickly award the contract by default to Onderdonk. "The Metropolitan Company," he wrote to Orr on January 16, "will . . . I promise you . . . do all in its power to aid the work, no matter which bid you accept . . ."⁵⁹

August Belmont and the RTC, however, were not so quickly or easily defeated. Under the terms of the advertisement for bids, the successful bidder was allowed ten additional days to deposit the \$5 million construction bond. Taking advantage of this provision and additional time in excess of the terms of the advertisement,⁶⁰ a privilege which the RTC would hardly have granted to McDonald alone, Belmont organized a construction company with an initial capitalization of \$6 million -- the Rapid Transit Subway Construction Company.⁶¹

A man of his stature in the financial world experienced little difficulty in finding important men, representing equally large and powerful interests, to subscribe to the sixty thousand shares of stock. The list of incorporators, directors, and stockholders constituted a union of New York's real estate, railroad, and financial interests, all of whom were connected in some way with the various business enterprises of August Belmont and Company: associates of E.H. Harriman and J.P. Morgan; Cornelius Vanderbilt; Baldwin of the Long Island Railroad; Walter G. Oakman of the Long Island, Brooklyn Rapid Transit Company, and the Guaranty Trust; Charles T. Barney, real estate baron and President of the Knickerbocker Trust; Gardiner M. Lane of the Boston banking firm of Lee, Higginson, and Company; George Young, of the United States Mortgage and Trust Company; McDonald; and Andrew Freedman.⁶² The four incorporators -- Belmont, the President, Barney, McDonald, and William Read -- subscribed for one hundred shares each; Freedman took 1500, and the others varying amounts which did not reveal their precise contribution to or interest in the concern. The complete issue of stock, excluding

director's qualifying shares of ten each, was immediately turned over to three voting directors, presumably August Belmont's employees, who held the stock until it was purchased by the Interborough Rapid Transit Company, Belmont's operating firm, in 1902.⁶³

Formation of the construction company allowed Belmont to do three very important things. He bypassed the recalcitrant bonding companies under Whitney's influence, he made John McDonald into a salaried employee, and, by doing so, he established a construction company which, because its reason for existing was to provide bonds for one of its own employees, achieved the remarkable feat of bonding itself.

By means of the Construction Company and with the help of the RTC, Belmont quickly disposed of the problem of the surety companies. The RTC asked the Supreme Court to remove the provision for double surety from the \$5 million construction bond, and also to reduce the amount assumed by each surety from \$500,000 to \$250,000.⁶⁴ The Construction Company then took on \$4 million of the construction bond and, as aforementioned, made the \$1,000,000 security deposit, which was in reality Belmont's own money. The rest of the construction bond -- \$1,000,000 -- was provided by four surety companies -- Freedman's United States Fidelity and Guaranty Company, The American Surety Company, The City Trust, Safe Deposit and Surety Company of Philadelphia, and the National Surety Company.⁶⁵ By giving over to the city his interest in the subcontractor's bonds -- a total of \$3,769,250 in bonds -- McDonald in effect raised the continuing bond of \$1,000,000 by himself, with Perry Belmont providing double indemnity.⁶⁶

In return for its help in allowing him to begin construction, McDonald became the Construction Company's -- that is, Belmont's -- employee. By an agreement of February 21, 1900, between him and the Rapid Transit Subway Construction Company, he was required to hand over to the company all payments from the city to him. All subcontracting arrangements were to be handled by the company, or by him only with its approval. In case of his illness or death, his contract with the city was automatically transferred to the company, which was to retain said document in the offices of August Belmont and Company. Seventy-five percent of the profits from construction were to be surrendered to the company, with the remaining twenty-five percent going to McDonald, except that supervisory expenses -- paid to August Belmont and Company -- and McDonald's annual salary of \$25,000 were first deducted. If the company assumed the lease of the completed road, or sold it, one quarter of the value of the lease issued in stock in the event of company operation, or one quarter of the cash or stocks received from sale of the lease, was to go to McDonald, who was then to pay one fifth of his quarter to Belmont, who would in turn repay one quarter of his fifth to McDonald, and another quarter to Freedman.⁶⁷

After relinquishing any and all authority which his contract with the RTC accorded him, and after surrendering a considerable share of his financial interest in the subway to August Belmont, John McDonald was at last permitted

to begin construction of New York's first subway. "Contract One" was signed on the same day as the contractor's agreement with the Construction Company, and formally executed three days later on February 24.⁶⁸ One month later, Mayor Van Wyck officially initiated construction in front of City Hall.

Most of the profits from construction, then, were to go to the company rather than McDonald, and these turned out to be quite as substantial as had been expected. Leaving aside disbursements for real estate and terminals, the city paid out almost \$34.5 million for originally stipulated construction related to "Contract One," and nearly \$4.3 million for extra work. The Construction Company disbursed an aggregate sum of \$23,822,915 to sub-contractors, to which an indefinite amount must be added, depending on how great a percentage is allowed for supervisory and administrative expenses. Since profit on extra work was limited to ten percent, an estimate of the Construction Company's profit must fall within the range of \$7 to \$9 million, with the average therefore close to the \$8 million that was anticipated.⁶⁹ As critics of "Contract One" would later point out, all or most of the sum was money that could have been retained by the city, had it chosen to sub-contract the work by itself and, as was done earlier in Boston, lease the completed subway to a private operator.⁷⁰

Belmont, however, already had in mind several important uses for this money. The RTC's original idea was that the lessee's profit on construction should be used to pay for the cost of equipment, thus freeing him from the task of raising capital before the railroad was in operation and earning profits. But long before the "Contract One" subway was completed, Belmont had exhausted its actual and potential construction profits in additional ventures -- extension of the first subway below City Hall and into Brooklyn, absorption of the Manhattan Elevated lines, purchase of numerous surface railways in Queen -- which would, he hoped, result in his securing a rapid transit monopoly in Manhattan and the Bronx, and the start of a similar transit empire in Brooklyn and Queens. To realize his larger plans, however, he needed a more adequate -- that is, a more highly capitalized -- vehicle than the Construction Company, and also a corporation which would allow him to operate the "Contract One" subway once it was finished. And here he was faced with a second unanticipated problem.

At the outset it was not Belmont's intention to become involved in construction. Whatever arrangements he may have made with McDonald either before or after January 15, 1900, his real aim was not to construct but to operate the subway. The problem with the surety companies had compelled him to form a construction company, and in assuming this responsibility, he also assumed control over the entire process of construction.

As he and his lawyers soon discovered, however, the very existence of the construction company created difficulties with regard to operation. His assumption was that the incorporators of the construction company could simply do double duty as the incorporators of the operating company, taking the lease for operation from McDonald. But this could not be done, because

according to the Rapid Transit Act the contract could not be transferred in part -- merely the operating lease -- but only in its entirety, and if the same parties as those involved in the construction company were to take over McDonald's entire contract, they would cease to be able to act as the contractor's bonding agents. Moreover, as the contractor for the subway already in construction, McDonald had technically been granted a franchise for the operation of a railway in New York. The operating company which Belmont planned to form to assume the lease would not possess a similar charter. Unless the law were altered, the only company that could take over the entire contract from McDonald and run the road, was a railroad corporation previously chartered for operation in the city.⁷¹

Neither the RTC nor Belmont were successful in their attempts to change the law. Both the legislature and the governor refused to consider it, again probably because of the influence and opposition of the Metropolitan Company, which as before hoped either to delay subway construction or to profit from the difficulties it created for Belmont by somehow capturing the work for itself.⁷²

For the second time, Belmont proved himself capable of beating the Whitney-Ryan syndicate at its own game. If, as appeared likely, there was no possibility of modifying the law to suit his needs, the other alternative open to him was to find an already incorporated and franchised railway, which would be legally empowered to assume McDonald's contract and run the subway. Since the transit monopolies controlled most of the city's railways, this was no easy matter, and even if he could find such a railway, were it known that he was interested in purchasing it, the existing shareholders would doubtless request an astronomical price. With no intention to flatter and with the implication of deviousness, Ray Stannard Baker would later describe the banker as "the silent Belmont."⁷³ On this occasion, however, his "silence" served him well. Belmont found two little railways in the Bronx -- the City Island and Pelham Park railway companies -- which the transit monopolies had ignored, and which, if the business were handled correctly, could be bought for a song. By purchasing shares in these unprofitable and practically defunct railways through intermediaries, and by keeping the matter secret even from many of the directors and shareholders of the construction company, by December 1901 Belmont managed to acquire ninety-five percent of the stock of the two companies for the paltry sum of \$272,000.⁷⁴ With these certificates in hand, he was now in position to turn the tables on the Metropolitan and indulge in a little arm twisting of his own. He visited his personal friend and fellow sportsman William C. Whitney,⁷⁵ informed him of his coup in acquiring the two franchises, and left with Whitney's promise, promptly honored, that the Legislature would easily pass legislation modifying the Rapid Transit Act in 1902.⁷⁶

Unfortunately for Belmont, this would not be the last of the Metropolitan's efforts to foil his larger plans, but his success in purchasing the City Island and Pelham Park railways did at least end its attempts to impede or prevent his direction of the first subway. More important, purchase of the City Island and Pelham Park was the key that enabled him to pursue and in part successfully

achieve his larger plans. It allowed him to form an operating company over which he had complete control, and to eliminate any interest in "Contract One" still remaining to McDonald and the original syndicate of January 1900.

In May 1902, directly after the Legislature passed the necessary modifications of the Rapid Transit Act, Belmont officially organized the operating company, the Interborough Rapid Transit Company or IRT, with an initial capitalization of \$25,000,000 divided into 250,000 shares, which was augmented in August 1902 to \$35,000,000 in 350,000 shares.⁷⁷ The stock was distributed as follows:

- 1) 96,000 shares or \$9.6 million in exchange for the stock of the Rapid Transit Subway Construction Company, representing a partially paid-in capital of \$3.6 million plus a three-quarter or \$6 million share of the anticipated \$8 million construction profits from "Contract One." The total book value of construction company stock was \$6 million, with sixty percent of the subscriptions paid in. This stock was exchanged for IRT stock at 160 percent of par, or for each 100 shares of construction company stock, stockholders were issued 160 shares of IRT stock.
- 2) 25,000 shares or \$2.5 million, giving the IRT complete control over "Contract One" and the lease to run the subway, issued to the members of the original syndicate of January 1900 as follows: Andrew Freedman - 6,012; Perry Belmont - 952; August Belmont - 4,405; C.W. Morse - 1,905; H.G. Runkle - 952; John Peirce - 1,905; John B. McDonald - 6,965; Howard Carroll - 952; Cornelius Vanderbilt - 952.
- 3) 15,000 shares or \$1.5 million to August Belmont, as compensation for cash outlay to purchase City Island and Pelham Park Railways (\$272,000) and for the efforts of his firm in securing the lease for the IRT of "Contract One" and for organizing the IRT, including exchange of stock with the Rapid Transit Subway Construction Company, and the securing of cash subscriptions to IRT stock.
- 4) 22,000 shares at \$110 a share or \$2.42 million to August Belmont and Company.
- 5) 2,000 shares or \$200,000 to August Belmont and Company, but bought by the firm for the Board of Directors of the IRT, in order to establish director's qualifying shares.
- 6) 190,000 shares or \$19,000,000 sold at par, mainly to stockholders of the Rapid Transit Subway Construction Company.⁷⁸

This allocation of stock and certain features of the IRT's organization require further comment. First, the exchange of IRT for construction company stock at 160 percent of par looks worse than it actually was. Since the

directors and shareholders of the construction company were virtually identical with those participating in the new organization, the operating company did not suffer but profited from absorption of the prior company, to the tune of \$3.6 million in paid-in capital, and its anticipated and probably actual three-quarter or \$6 million share of \$8 million construction profit. Despite later criticism of this exchange,⁷⁹ it was fair and equitable, since the probable cash return to the IRT was precisely the value of the stock. The same may be said of the 25,000 shares paid to McDonald and his original syndicate. In order to operate the road, it was absolutely necessary for the IRT to buy McDonald's interest in the "Contract One" lease. The 1902 modification of the Rapid Transit Act allowed the IRT to run the road without using the City Island and Pelham Park franchises, but it did not remove the provision that it assume responsibility for the entire contract. By the terms of the earlier agreement of February 21, 1900 between McDonald and the construction company, he and his syndicate were to retain one-fourth of the operating profits, and the construction company three-fourths. But the legal problems regarding operation had nullified this agreement, and as the principal to "Contract One," McDonald was entitled to the full benefits of its operation. Twenty-five thousand shares to the men who had initiated the project was small payment for a lease that gave the IRT legal existence, and which allowed it complete control of all profits from construction and operation.

The 15,000 shares issued to Belmont represented a sum far in excess of the actual purchase price of the City Island and Pelham Park railways, but it was not an immoderate price, given the business standards of the day, for his services in making the IRT possible and in organizing the company. This, at any rate, was the decision of the courts after years of litigation initiated by minority stockholders in the IRT.⁸⁰ The procedure by which the IRT was established gave Belmont's banking house the power to buy any corporation that it deemed necessary or useful to the formation of the company, and to sell this corporation or corporations to the IRT "without accountability in respect thereof . . . for such price as they deem reasonable and proper."⁸¹ Belmont was therefore in complete control, without accountability to directors or stockholders, of the cash value of the three companies bought in order to form the IRT -- the Construction Company, the City Island, and the Pelham Park, worth roughly \$3.9 million. Had he desired to exploit this advantage, he could have charged the full \$3.9 million rather than \$1.5 million for his services in bringing the IRT into being. This clearly confirms the later decision of the courts.

Belmont was also justified in claiming in October 1904, at the time of the subway's official inauguration, that the initial capitalization of the IRT did not include any "watered" stock.⁸² The \$35 million capital value left the new corporation with \$25.2 million in cash, excluding normal broker's fees for Belmont's firm, and with some \$8 million in anticipated profits from construction, or an aggregate sum of slightly more than \$33 million. Equipment for the "Contract One" subway and for its extension from City Hall under lower Manhattan and across to Brooklyn, the "Contract

Two" subway, cost the IRT over \$26.5 million, a figure much higher than had originally been estimated.⁸³ And since the company bid only \$3 million for the second or extended subway, which cost at least three times that figure to construct, by the time the "Contract Two" subway was completed, the initial capitalization of the IRT was in fact almost precisely equivalent to the actual costs incurred by the company.

In planning the first subway, the Rapid Transit Commission had to forego underground construction from City Hall to the Battery under lower Broadway. In January 1901, with roughly \$8 million available for additional construction, the Board took steps to rectify this omission, and also to extend the first subway under the East River to connect Manhattan's business district with the business center of the now consolidated borough of Brooklyn. The new line was to be a two-track road, running from City Hall down Broadway to the Battery, under the East River to Joralemon Street, following Joralemon to Fulton Street, then under Fulton to Flatbush Avenue, and under Flatbush Avenue to Atlantic Avenue, where it could leave passengers near the Brooklyn terminal of the Long Island Railroad.⁸⁴ Though it was estimated that this second road would cost \$9 million to build, and though the RTC did not have these funds in full, it rightly expected that this time around there would be competition, and that the bids would be much lower than before. The route, which connected two great business districts and the city's two most populous boroughs, was bound to be both popular and profitable. In addition, the Brooklyn Rapid Transit Company, which monopolized surface and elevated transit in that borough, would be obliged to bid, if only to keep outsiders from invading its territory. The Board knew, too, that Belmont would bid, and bid low, so as to retain control of underground rapid transit for himself and his construction company.

It may be said, indeed it was said,⁸⁵ that the RTC made its plans with Belmont in mind, and that Belmont, cognizant of this, tailored his bid to its needs. He wanted a monopoly and was both willing and able to make a low bid. He was counting on using either construction profits from "Contract One" or on capitalization of the IRT to build the road, and he was sure that future profits were well worth the small risk involved. The RTC had nothing against monopolies, and was looking for a good bargain. Both parties got what they wanted.

In response to ever growing public sentiment in favor of limited franchises, the RTC shortened the lease for "Contract Two" to the extent that this was allowed by the Rapid Transit Act -- to thirty-five instead of fifty years. Also out of respect for public opinion, it held extended hearings regarding the contract, and provided the Brooklyn Rapid Transit Company with every opportunity save one to enter into honest and fair competition with Belmont.

It could not, nor did it want to force him to share the line with the BRT, and he, acting out of his own quite understandable motives, could not be persuaded by the Brooklyn company's gentlemanly offers of cooperation. The Brooklyn firm could not count on profits from construction of the first

subway, and thus could not afford to bid as low as Belmont. It asked \$8 million; and he asked \$3 million.⁸⁶ Without Belmont's cooperation, the Brooklyn company suffered from the disadvantage that its offer threatened to upset the Commission's plans for a unified subway system with a single five-cent fare. If the BRT won the contract, New Yorkers would have to pay five cents to ride Belmont's subway from the Bronx to City Hall, and another five cents from the City Hall to the Battery or Brooklyn.⁸⁷ Given these conditions, there really was no choice, and Belmont, as planned was awarded the contract on September 11, 1902.

By the late fall of 1902, then, Belmont was a happy man. With the IRT in place, with "Contract Two" in his pocket, there was only one further step he needed to take to have the real makings of a rapid transit empire. He had only one worry, which was that the completed subway might encounter competition from the newly electrified Manhattan elevated lines. After ten years of bad, slow service, lowered profits, and decreasing passenger traffic, the Manhattan had slowly electrified its road and by 1902 was experiencing a surprising comeback. In this year its traffic augmented by thirteen percent, and its operating expenses showed a far less substantial increase in comparison to revenue than for any year of the previous decade.⁸⁸ Its management was talking more seriously than ever before about a third track for all the lines, in addition to the existing third track on Ninth Avenue.

The management of the "els," however, had good reason to feel as worried about Belmont as he felt about them. Electricity, it was true, was beginning to help them hold their own against the surface railways, and third tracks would provide their road with express service everywhere. But a third track railway in narrow streets, running express service at limited intervals, could not compete with a four track underground, with constant express service at much faster speeds than the "els" could manage. Moreover, the increase of the elevated lines' passenger traffic came after subway construction had begun but before the subway was in operation; it was difficult to foresee if the growth of the city would allow both the "els" and the subway to coexist and prosper. At any rate, the recently improved conditions of the elevated road was an argument for making hay while the sun shined: the present was the best time for the management of the Manhattan to strike a deal with Belmont, which is exactly what they set about doing.

After fairly hasty negotiations, the IRT agreed to absorb the entire Manhattan road, with all its lines and equipment, for the duration of the 999 year franchise dating from 1875. Because of the Manhattan's good financial showing in recent years and its technical improvements, the terms were favorable, as its management had hoped and more or less expected. Moreover, Belmont was hot in pursuit of empire and, fresh from triumph with "Contract Two," perhaps not overly cautious. In absorbing the elevated railroad he undertook obligations which would not offset large short-term profits, but which would constitute a considerable burden for the IRT in the long run. The

dividend of the Manhattan's shareholders was guaranteed at not less than six percent annually or more than seven percent on the capital stock of \$48 million in January 1906, and seven percent yearly thereafter. The IRT also agreed to pay the interest on the Manhattan's bonded debt of \$39,545,000, with the elevated road responsible as before for the principal.⁸⁹ The lease was signed on January 1, 1903, and took effect in April of the same year.

With this lease and with the beginning of the operation of the IRT one and one-half years later, August Belmont, its President, achieved his aim. He became the undisputed master of rapid transit in New York.

EPILOGUE

On the night of the day that New York's first subway was officially inaugurated, October 27, 1904, August Belmont was feted by the Board of Directors of the IRT and by the members of the Rapid Transit Commission at a ceremonial dinner in his honor, held at Sherry's Restaurant, the elegant dining establishment of New York's elite. As might be expected, the occasion was a happy one for the participants, who spoke freely, more fully, and with less modesty of their accomplishments in these private surroundings than they had at the public ceremony earlier in the day. Mutual admiration was the spirit of the moment, except that August Belmont, in particular, was the object of everyone's extravagant praise. At the end of the evening he was presented with a silver loving cup, as a token of his fellow director's appreciation for his "courageous" efforts in bringing both the subway and the IRT company to fruition.

In the world beyond the confines of this elite gathering, however, not everyone was as happy with the RTC's direction of the rapid transit decision or Belmont's business arrangements for the new subway company as the celebrants at Sherry's. Even the self-congratulatory addresses of these men were occasionally marred by defensive comments which took note of an influential and vocal group of critics. For by the time that the IRT opened for business, Progressive reformers and "muckrakers" had already begun to criticize both the first and second subway contracts, and to level harsh accusations against August Belmont and his mentors and allies on the RTC.¹

There was a good deal of truth in the Progressives' criticism. They were probably right when they made charges about prearranged "deals," and when they spoke of huge present and future profits being made by private individuals that should have found their way into the city's treasury. They were also right in perceiving that Belmont aimed at monopoly, that the existing Rapid Transit Act, with its insistence on a single contract for both competition from other and smaller sources of capital, and that the RTC was only too willing to cooperate with him. And they were right again in claiming that the rapid transit decision lacked boldness and imagination, and that the men responsible for it were incapable of achieving much beyond what politics and business "as usual" could accomplish.²

The men at Sherry's responded to such charges with uneasy wit and goodly amount of self-justification. Banker Jacob Schiff drew a hearty round of laughter³ when he described the typical Progressive critic as a "demagogue" who "comes into the land and . . . complains because this great franchise has been given away, because the men in control enjoy it without paying tribute to him."⁴

But he and Alexander Orr also made a more serious attempt to refute Progressive accusations. Schiff argued that Belmont and the RTC had done the best they could in the existing circumstances, and that Progressive

reformers failed to appreciate the political, economic, and legal obstacles that before 1900 had stood in the way of subway construction. He did not specifically remind the reformers of interference from the courts, of Tammany hostility towards the RTC, and of powerful interests like the Broadway property holders and the Manhattan and Metropolitan railways, which sought to impede and perhaps preclude the building of New York's first subway. He alluded to all of these, however, by speaking of "the slow and tedious development of underground transit," and the "difficulties which had to be overcome" before the subway could be realized.⁵

Alexander Orr also pointed out that "in charging the Rapid Transit Commission with having given a great asset belonging to the city to a favored few," the Progressives "had forgotten evidently", that the IRT had not exactly been besieged by willing and able bidders.

. . . instead of our having given a great asset to a favored few, I looked upon it -- and I believe that each member of the Rapid Transit Commission so looked upon it -- that instead of our favoring the gentlemen who undertook this great enterprise, they certainly favored and made successful the efforts of the Rapid Transit Commission. Had it not been for their action our Commission would have failed just as several commissions failed before; and I shall always feel . . . gratitude to these gentlemen who stepped in at exactly the right moment and filled the breach.⁶

Put another way, Orr's point was that in the circumstances existing in 1900 only a man such as Belmont was capable of carrying through the enterprise, and it was far better to have the beginnings of a comprehensive subway system built by a private capitalist pursuing his own monopolistic aims, than to have no subway at all.

The truth is that both parties were right, except that each judged the achievement of the IRT from a different perspective and neither the one nor the other fully understood that what was really at issue was the inadequacy of nineteenth-century institutions to meet the needs and expectations of a twentieth-century city. The rapid transit subway decision was one which tested the capacities of nineteenth-century capitalism and nineteenth-century urban politics to provide urgently required, large, and costly public services for the modern city of the twentieth century. Given the limitations which these institutions had shown in the past, at least so far as the provision of public transit was concerned, the rapid transit decision and the organization of the IRT were great achievements. At the same time they necessarily fell short of what the twentieth-century city needed and, perhaps more important, what the twentieth century public expected.

The IRT did represent the very best that the old system in both business and politics could attain. The cautious and conservative patricians of the RTC were honest and, for their time and class, public-spirited men.⁷ But they hardly possessed the will, imagination, or ability which would have allowed them to overcome their often snobbish distaste for the "regular" organization politicians of Tammany Hall. Nor did they see it was precisely at this moment that Tammany was beginning to change, becoming less corrupt and far more responsive than it once had been to the larger needs and demands of the public.

Again, for his time and place, a more fair-minded or enlightened capitalist than August Belmont could not be found.⁸ Compared to other transit magnates -- men like Whitney, Ryan, Brady, or Gould -- he was honest, generous, scrupulous about financial matters,⁹ and, as his grandson, August Belmont IV, would later say, concerned about rendering the public a service "while still making a buck for himself."¹⁰ Until he made or was forced to make mistakes, as when he merged the IRT with the Metropolitan Railway in 1905,¹¹ thereby assuming its burdens and becoming entangled in its policy of financial manipulation, he ran a clean and highly efficient company. He was telling the truth when he said at Sherry's that the IRT stock was not "watered," and "that every dollar put into the company is now represented by property or construction about to be furnished -- that is, the extension to Brooklyn, which is practically being built with the money of the company."¹² And his friend and colleague William Barclay Parsons was likewise truthful when he described Belmont as a generous man who never rejected a necessary improvement for the subway, even when there was no provision in the contract for recompensation from the city.¹³ From the vantage point of those raised in and accustomed to the old system, Belmont was, as the Commission believed, very much the right man for the job. But this, of course, was precisely what the Progressive reformers had against him. He was perhaps the best as well as the last of his kind, but he was, nevertheless, a transit magnate.

From the point of view of the public and the Progressive reformers who gave articulate expression to the public's needs and expectations, the IRT came too late and provided too little. At Sherry's Morris Jessup, then President of the Chamber of Commerce, expressed the belief that the new subway would allow

. . . the poorer classes, the working men of this city
. . . the opportunity of leaving their work in the busy
centres of activity and getting quickly out into the
bright sunshine and the air which will benefit their
lives and their health. The purer we can make the homes
of the people of this city, the better will be the
city.¹⁴

But the IRT, as will be shown in a subsequent report, would have little effect on the "congested condition" of the poor in the lower East Side. Progressive reformers shared Jessup's doubtless sanguine expectation that subways would

solve the problem of the slums by dispersing the poor to the better atmosphere of the northern suburbs. But unlike Jessup they at least recognized that nothing less than a comprehensive subway system would achieve this end.

For the Progressives the IRT was not a solution but part of the problem. It was only a "trunk line," built long after it could do much good in relieving traffic or slum congestion, and the conditions of its construction and operation were such as to relinquish profits that should have belonged to the city, and decisions that should have been matters of public concern, to a private corporation. The reformers held the RTC responsible. Its "business as usual" direction of the rapid transit decision had retarded construction of even this inadequate underground road. And its collusion with Belmont allowed him to garner the lion's share of profits from the new subway, when these same profits, if returned to the city, could have been used to hasten more comprehensive subway construction.

Municipal ownership" clearly meant one thing to the Progressives, and something else again to the patrician businessmen of the RTC. The principle of municipal ownership embodied in the Rapid Transit Act of 1894 was conceived by its framers as an expedient which would help to stimulate private capital's interest in subway construction. Though it signified a small step towards governmental participation in the creation and control of public works, it was meant to aid rather than restrict, much less supplant, private enterprise. As understood by Progressive reformers, however, municipal ownership was much more than an expedient, and was no longer geared to the interests of private capital. It was perceived as a method of securing for the city reasonable rates and a large share of profits from the operation of public utilities, and also as a means of achieving public control over public services. It signified a new and important role for government.

Set against these standards, the IRT was necessarily considered a failure. "Contract One's" long fifty-year lease, and the renewal option of an additional twenty-five years, was characterized by one Progressive journalist, Ray Stannard Baker, as "a contract by which, in effect, the city has actually conveyed its right to govern."¹⁵ Reformer and City Comptroller Edward Grout expressed a similar view in a letter published in the Times.

I know it is the fashion to speak of this subway as an instance of municipal ownership. It may be such three generations hence. Today it is merely a lending of municipal credit with exemption from taxation for the benefit of individuals. Municipal ownership means something more than naked ownership. It means ownership for the benefit of the city, not for the benefit of a private corporation When the voters of New York voted for municipal construction of a rapid transit road, how many of them contemplated the result which now exists?¹⁶

The decision for the IRT, then, marked an ironic turning point in American and New York City history. The IRT was the first subway in New York, and the beginning of a subway system that must still be seen not only as one of the great public "improvements" of the twentieth century, but also as an indispensable element in the life of America's largest and, as some still believe, greatest city. Yet the story of the IRT has really very little to do with the twentieth century and in one important sense its creation signified an end rather than a beginning. Its achievement was the culmination of a long struggle for adequate rapid transit -- underground transit -- in nineteenth-century New York. It was the work of men whose world was defined and accordingly circumscribed by the practices, ideas, beliefs, expectations, and circumstances of the nineteenth-century. But in the very process of deciding upon and bringing the new subway into being, these men aroused public expectations that neither they nor the system they represented could satisfy. Their success was ironically the cause of their undoing. In time, and with the advent of a new era which historians have called "The Age of Reform," these same expectations would result in a far more important role and ever more substantial responsibilities for government. The story of the IRT is thus one small but significant chapter in a larger history which records the slow transformation of American urban society, and which marks the gradual shift from the old liberalism to the new.

Part II, i

¹The question of the respective roles of businessmen, politicians, and experts in city government was widely discussed and debated in the period. In Europe since the Middle Ages it was customary for businessmen to involve themselves in municipal affairs, and as both the German and English upper middle classes had demonstrated, in the nineteenth century they often combined this activity with considerable professional expertise regarding urban problems -- to wit, the career of Joseph Chamberlain in Birmingham. See Asa Briggs, Victorian Cities (New York: Harper and Row, 1970), pp. 187-238. In America, however, businessmen eschewed politics for profit, and there was only the choice between corrupt "professional" politicians and more disinterested often apolitical professionally educated experts. The opinion of C.W. Sweet, the editor of the Record and Guide, was typical: "The view that it is in business men we must trust for our municipal well-being has some foundation in history. Public corporations have in the past been directed almost entirely by the local commercial interests. It was these interests that created the cities, won corporate rights and charters from the Kings and noblemen, and then took care of the things which they had made. In Europe the forms of their administration

still remain, and the tradition is so soundly based in the ideas and habits of the European city residents that these forms have been in many cases successfully adapted to the new conditions. But in this country we are rapidly fastening upon ourselves a tradition of a very different character, and one which it will be very difficult to shake off. For a great variety of reasons our business men have not taken any general and considerable interest in local affairs. . . . The conditions in our American cities have always differed in most important ways from the conditions prevailing in European cities. Our public corporations have never had to fight for their rights and privileges, and hence the different trades never had to organize closely so as to obtain recognition and maintain their grants of power. The legislatures were, in the beginning, willing to give them liberal charters, and our business men were left entirely free to push their own private ends. At the same time the undeveloped state of the country and its great resources offered large rewards to those who would devote all their energies to business. Broadly speaking, the indifference of our commercial classes to the responsibilities of managing their local affairs has been due to these two causes -- their absence of any necessity for organized co-operative action, and their enormous material success. . . . It was inevitable under such circumstances that gradually another class would step into the places that business men failed to fill; and such a class is now in complete possession. But these politicians instead of being qualified for the important positions that they fill, have been brought up in the worst possible training school for such responsibility. They owe their best energies to their organization, and their manner of life and associations divorce them most effectually from the intelligence, knowledge, and public spirit of the community. . . . Under present conditions business men will and should have no important share in the management of our great cities. The directors of our city government must be men who are not hampered by large private interests; they must be able to give their best energies to the municipal business, and they must be men who are specially trained and qualified for the positions they occupy. . . . Business men cannot obtain this training. Our cities will have to be managed by what will practically be a class of experts; and if such a class ever comes into power, the politicians must, of course, go. . . ." See Record and Guide, LI (June 10, 1893), 901-902. See also the article entitled "Business and Politics" in Record and Guide, LI (January 14, 1893), 37-38.; and Record and Guide LV (February 23, 1895), 285-286.

The entire question of the role of the economic and business elite in American urban politics is the subject of David Hammack's dissertation, "Participation in Major Decisions in New York City, 1890-1900." Hammack intelligently reviews the theories of Bryce, Ostrogorski, Lincoln Steffens, William Allan White, Arthur Schlesinger, Sr., Robert Dahl, Nelson Polsby, Wallace Sayre, and many others, and, after studying two major New York decisions -- the consolidation of Greater New York and the centralization of the public schools -- concludes that earlier opinions on this question did not fully elucidate the complexity of the situation. Hammack shows that the economic and business elite played an important though not preponderant role in urban politics, that they were often active politicians as well as powers behind the scenes or molders of public opinion, that professional experts were obliged to consult with them and consider their views and interests, and that the "professional" machine politicians

were both more interested in policy and, at the same time, less monolithically organized than has been assumed, all of which corrects the contemporary view expressed by C.W. Sweet above. Hammack also shows that an organization such as Tammany expressed the interests and allowed for the participation of the rising middle classes of the city, and that workingmen were, except on rare occasions, excluded from active political participation either in regular or elite political organizations. See Hammack, "Participation in Major Decisions," esp. pp. 9-112, 409-446. What Hammack does not say, but what his study implies, is that urban politics, however competitive and "pluralistic," took place wholly within the limits of the capitalist economic and social system, and that, in this sense both professional experts and political bosses, however independent politically from the economic and business elites, nonetheless served their larger interests.

² Ely and Shaw were representative of a new generation of scholars and journalists, who at the end of the nineteenth and the beginning of the twentieth century attempted to impose the professional standards and organization of the European and especially the German university on the American college, and who also familiarized literate Americans with European economic, social, and political thought that was critical of popular doctrines such as laissez-faire and the non-interventionist state. Both Ely and Shaw were associated early in their careers with Johns Hopkins University, which was perhaps the first center of professional graduate education in the liberal arts in the United States, and where the professional standards of German universities and German "municipal reform" were highly esteemed. For Ely's career, see Benjamin C. Rader, The Academic Mind and Reform: The Influence of Richard T. Ely in American Life (Lexington, Kentucky: University of Kentucky Press, 1966).; For Shaw, see Graybar, Shaw. For the professionalization of American higher education and its relation to reform, see Burton Bledstein, The Culture of Professionalism: The Middle Class and the Development of Higher Education in America (New York: W.W. Norton, 1976).; and Christopher Lasch, "The Moral and Intellectual Rehabilitation of the Ruling Class," in The World of Nations (New York: Alfred Knopf, 1974), pp. 80-102. The Record and Guide often published large excerpts from Ely's and Shaw's articles and books, and on one occasion serialized an entire book by Ely on property. See Record and Guide, XXXVIII (October 9, 1886), 1226-27; XLI (March 31, 1888), 388-89; XLIII (January 26, 1889), 104; XLIII (February 23, 1889), 239; XLIV (December 28, 1889), 1735; I (August 20, 1892), 235-236; LV (February 23, 1895), 285-286; LVI (December 28, 1895), 924-925; and for the serialization of Ely's book, Record and Guide, LIII (March 17, 1894 - June 2, 1894).

³ See the discussion in Cynthia Morse Latta, "The Return on the Investment in the Interborough Rapid Transit Company" (Ph.D. diss., Columbia University, 1974), p.1 and 3n.

⁴ In Glasgow, in particular, for which see Albert Shaw, Municipal Government in Great Britain, pp. 156-157.; and Albert Shaw, "Municipal Socialism in Scotland," Juridical Review, I (January 1889), 33-53 and "Glasgow: A Municipal Study," Century Magazine, XVII (March 1890), 721-736.

⁵ Record and Guide, LI (March 18, 1893), 398.

⁶ Record and Guide, LV (February 23, 1895), 285-286.

⁷ See below, Epilogue.

⁸ By and large the patrician reformers were businessmen and were perfectly comfortable with the unregulated capitalism of the nineteenth century, whereas the Progressives tended to be professionals -- journalists, scholars, professionally trained corporate managers -- and were critical, though only mildly, of this system.

⁹ Key figures -- Seth Low, Abram Hewitt, Alexander Orr, Edward Shepard -- among the patrician reformers involved in the rapid transit decision were deeply involved in political activity, both out of motives of personal ambition and as political bosses, leaders of reform "machines." See Thomas J. Condon, "Politics, Reform, and the New York City Election of 1886," New York Historical Society Quarterly, XLIV (July 1960), 363-393.; and Hammack, "Participation in Major Decisions," pp. 421-426.

Part II, ii

¹ The medal was presented to Hewitt at Chamber of Commerce meeting of October 3, 1901. See New York City Board of Rapid Transit Railroad Commissioners, Report of the Board of Rapid Transit Commissioners of the City of New York, 1900-1901 (New York, 1902), pp. 103-109. (Hereafter cited as RTC, Report of 1900-1901).

² Hewitt to Reverend J.S. Morgan, 23 August 1895, Peter and Edward Cooper-Abram S. Hewitt Letter Press Copybooks, Manuscript Division, New York Historical Society

³ The standard biography of Hewitt is that of Allan Nevins, Abram S. Hewitt with some account of Peter Cooper (New York: Harper, 1935). For the discussion of his role in iron and steel manufacture, see especially Ch. VI.

⁴ See Hewitt's "Presidential Address to the American Institute of Mining Engineers, 1890," in Allan Nevins, ed., Selected Writings of Abram S. Hewitt (New York: Columbia University Press, 1937), pp. 124-136. Hewitt's position was, however, hardly as enlightened as Nevins, Hewitt, pp. 574-576., claims. Hewitt acknowledged in principle the right of workmen to have unions and to strike, but denied that unions could compel any individual workman to join a strike. See Hewitt, Selected Writings, p. 126.

⁵ Hewitt believed strongly in the classical thesis of individualism which posits that liberty depends upon property. Incensed by the West Virginia coal strike of 1894, he wrote to his friend and the manager of his coal properties, W.N. Page, that "in . . . parts of the country there seems to be an utter ignorance of the relation between property and liberty. They do not appreciate that there can be no liberty without property, and that the best guarantee for liberty is the protection of property." Hewitt to W.N. Page, 7 June 1894, Cooper-Hewitt Papers. See also "Liberty, Learning, and Property, in Hewitt, Selected Writings, pp. 316-337.

- ⁶ For Hewitt's comments on the relation of his plan to "municipal socialist" practice in English cities, see Hewitt to Richard Watson Gilder, 31 January 1895, Cooper-Hewitt papers.
- ⁷ The problem of "watered" stock or capitalization on the basis of anticipated earnings rather than actual assets and far in excess of the value of fixed capital or paid-in stock was the usual practice for private firms involved in public transit. It was also a practice common in the formation of other large enterprises in many industries of the era, as Alfred Chandler, Jr., "The Beginnings of Big Business in America," Business History Review, XXXIII (Spring 1959), 1-31., has shown. Hewitt addressed this issue in his speech before the Committee of the New York State Legislature supporting his rapid transit bill of 1888. Other advocates of his plan, such as Simon Sterne, also alluded to this practice, which they believed would necessitate much higher fares, as the total interest on false capitalization was passed along to the consumer. See Record and Guide, XLI (March 3, 1888), 264; XLI (April 7, 1888), 420.; XLI (April 28, 1888), 526.
- ⁸ I owe this formulation to Hugh Dunne of the Metropolitan Transportation Authority.
- ⁹ Hewitt prided himself on his independence from Tammany and all manner of special interests while in office, even though Tammany had helped to elect him. See Hewitt to William Hogg, 24 September 1888, Mayoral Papers of Abram S. Hewitt, Manuscript Division, New York Historical Society, in which he says "there is no good ground for the antipathy of the leaders in Tammany Hall, except the conviction which they have from experience that I can not be used for their personal advantage." Nevins, Hewitt, p. 501., indicates that Hewitt refused to accept a bill which would have empowered the Board of Aldermen to supervise construction of a rapid transit railroad. He did not trust "an elective assembly" controlled by Tammany with the direct expenditure of large sums for public works, and thus submitted his own bill, which was therefore bound to fail of passage. In addition to lacking Tammany's support, his own "reform" political faction, the County Democracy was waning in strength after earlier (in the 1870's) defeat in Boss Tweed (Nevins, Hewitt, pp. 500-503.), and he had no ties with Boss Platt's upstate Republican machine.
- ¹⁰ See New York City, City Record, February 1, 1888.; and Nevins, Hewitt, p. 499.
- ¹¹ City Record, February 1, 1888.; Nevins, Hewitt, p. 498.
- ¹² City Record, February 1, 1888.; Nevins, Hewitt, p. 498.
- ¹³ Nevins, Hewitt, p. 500. Hewitt announced his rapid transit plan in the Mayor's Annual Message to the Board of Aldermen on January 31, 1888. Four days earlier he wrote to Chauncey M. Depew, President of the New York Central, informing the latter that he had finished drafting the message, but would not show it to Depew, "so that both you and I (Hewitt and Depew) may be free to say that it was not the result of any previous discussion or understanding." Hewitt to Depew, 27 January 1888, Hewitt Mayoral Papers. This

remark may be interpreted as a mere strategem, useful in dealing with the public, but the more likely view, given Hewitt's character and typical conduct, is that he told Depew literally nothing about the plan before proposing it publicly.

- ¹⁴ Nevins, Hewitt, p. 501.; and interview with Depew in the New York Times, January 20, 1889. Ten days before Hewitt delivered his Message, Depew had indicated that the New York Central would not build a rapid transit railroad. See Record and Guide, XLI (January 21, 1888), 23. After Hewitt's Message was made public, he objected to the provisions in the Mayor's plan which called for a thirty-five year lease, saying that such a lease would not suffice to amortize construction bonds, and that the city would own a railroad for which the New York Central had paid.
- ¹⁵ RTC, Report of 1900-1901, pp. 104-106.
- ¹⁶ Letters; Henry R. Beekman to F. McIntyre, 15 March 1887; Hewitt to Alexander E. Orr, President of the Produce Exchange, 2 February 1888; Hewitt to Seth Low, 3 February 1888., Hewitt Mayoral Papers.
- ¹⁷ City Record, February 1, 1888.
- ¹⁸ Record and Guide, XLI (February 11, 1888), 173.; XLI (February 18, 1888), 210.; XLI (March 3, 1888), 263-264. See also New York Times, February 8, 11, 19, March 17, 1888.
- ¹⁹ Hewitt ended his Annual Message of January 31, 1888 with the following peroration invoking the "imperial destiny" of New York:

With its noble harbor protected from injury, and the channels of approach straightened and deepened; with its wharves and docks made adequate for the easy transfer of the vast commerce of the country; with its streets properly paved and cleaned, and protected from destructive upheavals; with cheap and rapid transit throughout its length and breadth; with salubrious and attractive parks in the centers of dense population; with a system of taxation so modified that the capital of the world may be as free to come and go as the air of heaven; the imagination can place no bounds to the future growth of this city in business, wealth, and the blessings of civilization. Its imperial destiny as the greatest city in the world is assured by natural causes, which cannot be thwarted except by the folly and neglect of its inhabitants.

See City Record, February 1 and February 18, 1888.
- ²⁰ Chamber of Commerce of the State of New York, Thirtieth Annual Report of the Corporation of the Chamber of Commerce of the State of New York For the Year 1887-'88 (New York: Press of the Chamber of Commerce, 1888), pp. xlv-xlvii.
- ²¹ Record and Guide, XLI (April 28, 1888), 526. See also Record and Guide, XLI (March 3, 1888), 264.
- ²² Record and Guide, XLI (April 28, 1888), 526.
- ²³ Record and Guide, XLI (February 11, 1888), 174.

- ³ Record and Guide, XLIII (January 5, 1889), 1.
- ⁴ Record and Guide, L (November 26, 1892), 682.
- ⁵ Record and Guide, XLIII (January 5, 1889), 1.
- ⁶ Record and Guide, XLIII (March 30, 1889), 425-426.
- ⁷ Ibid..
- ⁸ Ibid., p. 426
- ⁹ Record and Guide, XLV (May 24, 1890), 773-774.
- ¹⁰ Ibid., p. 773.
- ¹¹ Ibid., p. 774.
- ¹² See Mammack, "Participation in Major Decisions," pp. 420-431.
- ¹³ Record and Guide, XLI (April 28, 1888), 526.
- ¹⁴ Report of the P.S.C. 1907, I, 461-463.
- ¹⁵ Ibid..
- ¹⁶ Ibid. The Mayor first appointed Woodbury Langdon, but he could not serve and was replaced by Charles Stewart Smith, President of the Chamber of Commerce.
- ¹⁷ New York Times, December 15, 1890.
- ¹⁸ Mayor Grant first appointed Frederick P. Olcott, a "mugwump" Democrat and President of the Central Trust Company, who failed to qualify as a Commissioner (probably because of his interest in the Arcade Railway), and was replaced by John M. Inman, a cotton broker and "one of the best known businessman in the Wall Street district." William Steinway was a Tammany Democrat and head of the piano firm; Samuel Spencer was a Republican banker at Drexel, Morgan, and Company; John Starin was a Democrat and prominent businessman; Eugene Bushe, Democrat, was a railroad lawyer and real estate investor. See New York Times, January 6, 1891.; Walker, Fifty Years, p. 131.
- ¹⁹ New York Times, March 28, April 4, 11, 22, May 10, 1889; January 22, May 31, 1890.
- ²⁰ Report of the P.S.C. 1907, I, 462-463.
- ²¹ Parsons did engineering work for Hewitt on the Erie Railroad, and was also an alumnus of Hewitt's Alma Mater, Columbia College. (as were other figures prominent in promoting and implementing the rapid transit decision -- e.g., Alexander Orr, Seth Low, Morris Jessup, George Rives). "It gives me great pleasure," Hewitt wrote, "to state that I have known you for some years and have had experience as to your ability to fill a position of responsibility where engineering

- ²⁴ On O.B. Potter's role in the County Democracy and his relation to Hewitt and William C. Whitney, see Hirsch, Whitney, p. 181.
- ²⁵ Record and Guide, XLI (April 7, April 14, 1888), 420, 455.
- ²⁶ Record and Guide, XLI (February 4, 1888), 137.
- ²⁷ Record and Guide, XLI (April 7, 1888), 420.; XLIII (January 5, 1889), 1.
- ²⁸ Record and Guide, XLIII (January 5, 1889), 1.
- ²⁹ In 1894, when putting forth much the same rapid transit plan, Hewitt implicitly acknowledged that one problem with his 1888 scheme was the lack of advanced technology. "To the underground system," he said in 1894, "most of the objections which were originally urged, and which have been made against the underground system abroad, in London particularly, have ceased to have any weight. The improvements which have been made in regard to lighting and ventilation and motive power in the last six years have been so great, that I think I am justified in saying that the objections to the underground system which were of so strong a nature originally, may be said to be pretty much dissipated." Chamber of Commerce of the State of New York, Thirty-Sixth Annual Report of the Corporation of the Chamber of Commerce of the State of New York for the Year 1893-'94 (New York: Press of the Chamber of Commerce, 1894), p. 113 (Hereafter cited as C. of C., Annual Report 1893-94).
- ³⁰ See Condon, "Politics, Reform, and the City Election of 1886," pp. 363-393. For Hewitt's own comments on the Mayoral election of 1886, in which, supported by Tammany, he ran against Henry George and Theodore Roosevelt, see New York Times, October 5, 1897.
- ³¹ Hewitt to William Hogg, 24 September 1888, Hewitt Mayoral Papers.
- ³² Hewitt to Richard Watson Gilder, 31 January 1895, Cooper-Hewitt Papers.

Part II, iii

- ¹ In a letter of 24 September 1888 to William Hogg, Hewitt expressed the view that he did not "have the moral right to turn the city government over to any organization which will run it simply for what it is worth to the organization," and that, consequently, he was reluctantly accepting an Independent nomination for Mayor in order to fight Tammany. Hewitt to William Hogg, 24 September 1888, Hewitt Mayoral Papers.
- ² There was no love lost between Hewitt and Hugh Grant. Early in Hewitt's mayoral term Grant, then the Sheriff of New York County, had spoken out in behalf of Tammany against Hewitt's appointments, and Hewitt had been mightily miffed. See Hewitt to Hugh J. Grant, 1 June 1887, Hewitt Mayoral Papers.

training and knowledge were required. You gave entire satisfaction to the shareholders and officers of the company (the Erie Railroad), and I can therefore, from my own observation, say that any business which may be entrusted to you will be attended to with fidelity and ability." Newitt to William Barclay Parsons, 2 May 1888, Newitt Mayoral Papers.

²²See Hammack, "Participation in Major Decisions," p. 414.

²³New York City, Report of the Board of Rapid Transit Railroad Commissioners in and for the City of New York to the Common Council of the City of New York in Pursuance of the Provisions of Section 5 of Chapter 4 of the Law of 1891 (New York, 1891), pp. 3-6. (Hereafter cited as RTC, Report, 1891.). See also Record and Guide, XLVIII (August 8, 1891), 174-175.

²⁴RTC, Report, 1891, pp. 3-6.

²⁵RTC, Report, 1891, pp. 12-13. See also Passer, The Electrical Manufacturers, pp. 237-277.

²⁶RTC, Report, 1891, p. 1.

²⁷"Appreciating that a viaduct of masonry would be the most desirable means of transit, the commission considered many plans for such a route. An elevated structure on Broadway below Thirty-third street was prohibited by the Statute. A viaduct of masonry was manifestly impossible on any adjacent street. A viaduct through the blocks in the lower part of the city, the Commission believed, . . . to be too costly, and subject to too many delays in the acquisition of property rights, to be within reasonable hope of attainment."
RTC, Report, 1891, pp. 2-3.

²⁸See accounts of this criticism in Record and Guide, XLIX (June 25, 1892), 988-989., (September 10, 1892), 315-316., (September 24, 1892), 375., (November 19, 1892), 641-642., (December 3, 1892), 716. Most critical and most telling was the opinion of the Engineering News, XXVIII (November 24, 1892), 492, which set forth the following argument: ". . . the franchise is to be sold for the uncoscionable term of 999 years, without even a reversion of the works to the city at the end of that period. Now it is a fact readily demonstrated, both by reason and experience, that the attractiveness of the enterprise to private investors would not be seriously diminished even had it been stipulated that the works should revert to the city at the end of 50 or 100 years. . . . The folly of granting a perpetual franchise to a private corporation, although often perpetrated, was foreseen and guarded against by the framers of the law from which the commission derives its powers. The law provides (section 7): All sales of such rights, privileges and franchises shall be made for a definite term of years. The sale of the franchise for 999 years conforms to the letter of the law, but it is practically a perpetual franchise, and as such a violation of the spirit of the law . . ."

²⁹Record and Guide, XLX (December 31, 1892), 872.

³⁰Barker and Robbins, London Transport I, pp. 305-315. The world's first electric underground railroad, the City of London and Southwark

Subway, ran at an average speed, including stops, of about 11 and 1/2 miles per hour, and its locomotives could only generate, at best, a speed of 25 miles per hour. It did not generate much passenger traffic -- the total of 5,161,000 for 1891 had grown only to 6,980,000 by 1899 -- and it also did not reward its stockholders with a large profit.

- 31 For the problem of Broadway property owners, see Record and Guide, XLVIII (August 8, 1891), 174., (October 24, 1891), 499., (November 1, 1891), 650., (November 28, 1891), 683., (December 5, 1891), 711-712.; and XLIX (February 20, 1892), 277-278.
- 32 Clarence E. McNeil, "The Financial History of the Municipal Subways of New York City" (Ph.D. diss., Yale University, 1928), pp. 26-27.; Brooks, "History of Street and Rapid Transit Railways," p. 206. It was assumed at the time that the Commission's plans for financing the subway were such as to preclude private capital's interest, thereby working to the advantage of the Manhattan Company, which was very much favored by Tammany.
- 33 Walker, Fifty Years, p. 136., quotes Parsons as follows: "All the employees of the Board, myself included, were dismissed, and in thirty days all were reappointed except me. The Board then offered the elevated railroads rights for important extensions. Having failed to enlist capital for an underground road, the Board did what was expected of it and made elaborate plans for extending the elevated railroads. Then another strange event happened. The elevated railroad interests, then dominated by Jay Gould and Russell Sage, refused to build the extensions offered. . . ." As will be seen below, p. 135, other patrician reformers -- Abram Hewitt and J.H. Rhoades, shared Parsons' view of the 1891 RTC.
- 34 Record and Guide, L (December 24, 1892), 836.
- 35 See the Record and Guide's campaign for public ownership, XLIX (May 7, 1892), 720., (May 28, 1892), 845.; L (September 17, 1892), 344., (November 19, 1892), 641., (November 26, 1892), 682-684., (December 3, 1892), 715., (December 10, 1892), 759-760., (December 24, 1892), 835-836. See also New York Times, January 4, 17, 21, 1893.
- 36 Schiff's views are commented upon in the Record and Guide, XLVIII (September 26, 1891), 370. Schiff reiterated his remarks of March 1891 in his speech before the Chamber of Commerce in 1894, at the time when that body was considering the plan of R.T. Wilson. See C. of C., Annual Report 1893-94, p. 95. The Cincinnati-Southern was built by the city of Cincinnati and leased to a private operator.
- 37 In March 1891 Schiff wrote Mayor Grant expressing his doubts about the availability of private capital for subway construction. He believed that capitalists would not invest in a subway, but if they did, "as compensation for risks they would have to take," they would "require the creation of a large amount of fictitious capital, upon which (would be paid) as large a return as the growth of traffic shall be expected to permit. Jacob Schiff to Mayor Hugh Grant, 16 March 1891, Mayor's Papers, Box 6187, Municipal Archives of the City of New York.

³⁸Ibid.

³⁹Record and Guide, L (November 26, 1892), 682-683. Many of the same views were expressed in 1894 as well -- for example, by John Inman and Alexander E. Orr, two of the men who would attempt to implement the Act of 1894 after it was passed. See C. of C., Annual Report 1893-94, pp. 118-121.

⁴⁰Letter, William Barclay Parsons to Edward M. Shepard, 26 February 1899, Edward M. Shepard Papers, Manuscript Collection, Columbia University.

⁴¹C. of C., Annual Report 1893-94, p. 121.

⁴²Ibid., p. 96.

⁴³Ibid., pp. 96-99.

⁴⁴Ibid.

⁴⁵Hewitt to Parke Godwin, 15 November, 1888, Hewitt Mayoral Papers.

⁴⁶Hewitt to George Foster Peabody, 16 February 1894, Cooper-Hewitt Papers.

⁴⁷Hewitt to Morris Jessup, 21 February 1894, Cooper-Hewitt Papers.

⁴⁸McNeil, "Financial History," pp. 33-34.

⁴⁹C. of C., Annual Report 1893-94, pp. 116-117.

⁵⁰C. of C., Annual Report 1893-94, p. 116.; and Hewitt to Morris Jessup, 21 February, 1894, Cooper-Hewitt Papers. "I have already had some conversation with Mr. Corbin," Hewitt wrote, "and I have every reason to know that he will compete for such a contract."

⁵¹New York Times, April 4, 6, 1894.

⁵²New York Times, April 6, 1894.

⁵³Ibid.

⁵⁴RTC, Report of 1900-1901, p. 15.

⁵⁵John M. Inman of the RTC, referring obliquely to the Corbin syndicate, explained that "it was assumed that, if passed, the law would be substantially as it had been framed, investing the commission with discretion to employ the city's credit or to deal wholly with a private company, as might seem the better way. The referendum amendment having upset all plans and having left the commission powerless to make any contract, and dependent upon the November vote to decide the character of contract that may thereafter be made, the syndicate was left without reason to exist." See New York Times, May 28, 1894.

⁵⁶Hewitt to Horace R. Fry, 8 March 1894, Cooper-Hewitt Papers.

- ⁵⁷ See Low's letter to A.E. Orr in C. of C., Annual Report 1893-94, pp. 137-138. "I believe," wrote Low, "that the city should itself own the proposed extension of its Rapid Transit system. Under no other conditions is a system likely to be devised and built with a large look ahead in the interest of the city, for private capital is almost certain to select the system which will be the most immediately profitable, and it may easily be that such a system may not be the best for the city."
- ⁵⁸ Steinway the pianomaker; John M. Starin, merchant and steamboat line owner; John H. Inman, prominent businessman -- all from the 1891 RTC. President Seth Low of Columbia College; Alexander Orr of David Dows and Company, investment brokers, who was also President of the Produce Exchange and President-Elect of the Chamber of Commerce; John Claflin, prominent merchant.
- ⁵⁹ RTC, Report of 1900-1901, p. 18.
- ⁶⁰ McSeveney, The Politics of Depression, pp. 87-133.
- ⁶¹ Record and Guide, LIV (October 13, 1894), 499.
- ⁶² A good example of the patrician view of immigration is provided in a letter from Abram Hewitt to George C. Ohren, in which Hewitt says that he approves of immigration as an economic measure which keeps down the every rising cost of labor (i.e., what a Marxist would describe as swelling the "reserve army" of labor), but that it has had adverse political consequences (i.e., the ascent of Tammany bosses), and that immigrants should not be allowed to become citizens, hence voters, either so easily or so quickly. See Hewitt to George C. Ohren, 25 January 1888, Hewitt Mayoral Papers.
- ⁶³ Buenker, Urban Liberalism, pp. 32-41.
- ⁶⁴ Harold C. Syrett, ed., The Gentleman and the Tiger: The Autobiography of George B. McClellan, Jr. (New York: J.B. Lippincott, 1956), p.245.

Part II, iv

- ¹ Rives was appointed to the RTC on November 19, 1896, after the resignation of Seth Low and the death of John Inman. He was a mugwump Democrat, a partner in the law firm of Olin, Rives, and Montgomery, a trustee of Columbia University, and had served as Under Secretary of State under Grover Cleveland.
- ² George L. Rives to Edward M. Shepard, 27 December 1901, Shepard Papers.
- ³ RTC, Report of 1900-1901, p. 16.
- ⁴ Buenker, Urban Liberalism, pp. 42-79.
- ⁵ New York Times, June 26, 1896.

⁶ William Barclay Parsons, Report to the Board of Rapid Transit Railroad Commissioners in and for the City of New York on Rapid Transit in Foreign Cities (New York, 1894).

⁷ See Parsons, Address, Purdue University, on Rapid Transit in Great Cities, pp. 1-2. "With the increase in population," Parsons said, "the keen rivalry of competition, and above all the growth of our corporate structures, there has come the realization that there must be something more in the way of a foundation than an enthusiastic dream; that the mistakes of the practical man, pardonable in small things, are too costly in great ones, and that there is needed, from the very beginning, the cold analytical methods of a trained and educated mind. The engineer of to-day, and more especially of the future, will, if he is to obtain the full measure of success that is rightly his, be concerned not only with his calculations, but will also have to study men and their needs; questions of industrial demand; the laws of finance and much in regard to general legislation. His it will be to conceive, to plan, to design, to execute and then to manage. In short, the engineer will find that his horizon is much more extensive than he can view it through the telescope of his transit, broader than he can lay it down on his drawing board. The more valuable is the engineer, in proportion as he can successfully master all the elements of his problem. Perhaps this applies nowhere with greater force than in transportation . . ." That Parsons was asked to speak at Purdue was significant, since this university was at the forefront in the Midwest (as MIT was in the East) among those institutions of higher education which were transforming engineering from a practical craft into a liberal science, and the engineer from a practical entrepreneur to a technocrat and corporate manager worthy of the developing American corporate structure. Though Parsons conceived of an engineering vocation which would contribute its part in creating the new corporate America, his vision of the engineering profession was still tinged with Saint-Simonian and Veblenesque idealism; he saw the engineer as a bold adventurer and universal man, with a comprehensive view of modern society which would equip him to reconstruct the world on equal, indeed perhaps on more than equal, terms alongside the great industrial magnates. Despite his insistence on rigorous professional training and a broad professional outlook, neither Parsons' views nor his career (which was spent as the master of his own firm, now Parsons-Brinkerhoff, in creating vast public works projects, of which the IRT was the first) conform precisely to the engineer as corporate servant and corporate manager, involved in "conscious social production," as described in David Noble, America by Design: Science, Technology, and the Rise of Corporate Capitalism (New York: Alfred Knopf, 1977).

⁸ See Hammack, "Participation in Major Decisions," pp. 414-420.

⁹ New York Tribune, October 10, 1894; New York World, October 10, 1894; The Commercial and Financial Chronicle, October 11, 1894; Record and Guide, LIV (October 13, 1894), 501-502.; New York Times, October 10, 11, 14, 1894. The Times gave Parsons' Report an entire page in its Sunday edition.

¹⁰ Passer, The Electrical Manufacturers, pp. 271-275.

¹¹ Ibid.

- ¹² New York Times, December 27, 28, 1894.
- ¹³ New York Times, December 27, 1894.
- ¹⁴ New York Times, December 28, 1894
- ¹⁵ Thomas Curtis Clarke was a rapid transit expert and consulting engineer, who had worked on the Willis and Third Avenue Bridge in New York, the West End Street Railway in Boston, and who also wrote engineering and rapid transit articles for journals. In this last regard, see the Record and Guide, XLIX (May 7, 1892), 720., (May 28, 1892), 845-846. See also Thomas Curtis Clarke, "Rapid Transit in Cities," Scribner's Magazine, XI (May-June, 1892), 568-578, 743-758.
- ¹⁶ Charles SooySmith was an old Columbia friend of Parsons. There is reason to believe that SooySmith helped Parsons in designing the subway, and it was to the former that Parsons conferred his subway designs when, in 1899, he left New York on an extended foreign tour to the Far East. See Parsons to Edward Shepard, 15 October 1899, Shepard Papers.
- ¹⁷ Hewitt to Octave Chanute, 11 March 1895, Cooper-Hewitt Papers.
- ¹⁸ Hewitt to Benjamin S. Henning, 2 March 1895, Cooper-Hewitt Papers.
- ¹⁹ New York Times, February 6, 1895.
- ²⁰ Hewitt to Benjamin S. Henning, 2 March 1895, Cooper-Hewitt Papers.
- ²¹ Letters; Hewitt to Louis L. Delafield, Secretary of the RTC, 21 February 1895, Cooper-Hewitt Papers.; Hewitt to Editor of the New York Times, 2 March 1895, Cooper-Hewitt Papers. See also New York Times, March 2, 3, 1895.
- ²² C. of C., Annual Report 1893-94, p. 137.
- ²³ New York Times, February 6, 1895.
- ²⁴ New York Times, February 17, 1895, March 23, 1895.; RTC, Report of 1900-1901, pp. 23-25.
- ²⁵ RTC, Report of 1900-1901, p. 25.; New York Times, November 14, 1895.
- ²⁶ See New York Times, December 20, 1895; January 9, 10, 14, 15, 16, 18, 26, 30, 1896; February 16, 1896.
- ²⁷ New York Times, May 23, 1896.; RTC, Report of 1900-1901, pp. 25-26.
- ²⁸ RTC, Report of 1900-1901, p. 26.
- ²⁹ With respect to Parsons' despondency, see New York Times, June 5, 1896; for Parsons' remark that the subway was his "life's work," see Parsons to Shepard, 26 February 1899, Shepard Papers. The Times reported that Orr was gloomy, but that he still believed that the RTC could go on with new plans either for underground rapid

transit in Elm Street or extension of the "els." See New York Times, May 23, 1896. Orr also admitted to being "less pessimistic" than Commissioners Steinway, Inman, or Starin, all of whom had already experienced failure when serving on the RTC of 1891. See New York Times, June 26, 1896.

³¹ New York Times, June 5, 1896.

³² New York Times, June 26, 1896.

³³ The remarks were attributed to John P. Leo, speaking for "the builders operating in the upper West Side." Record and Guide, LVII (May 30, 1896), 927.

³⁴ Stover's remarks were quoted in the New York Times, June 26, 1896.

³⁵ Orr brought up the matter of the lessee in replying to Stover. See New York Times, June 26, 1896.

³⁶ RTC, Report of 1900-1901, p. 20.

³⁷ See New York Times, February 6, 1895.

³⁸ As reported in New York Times, June 17, 1896.

³⁹ For report on Hewitt's testimony, see New York Times, February 16, 1896.

⁴⁰ Hewitt to Alexander E. Orr, 1 October 1896, Cooper-Hewitt Papers.

⁴¹ Hewitt to Alexander E. Orr, 7 October 1896, Cooper-Hewitt Papers. Charles Stewart Smith was a graduate of Rensselaer Polytechnic Institute, an engineer, and a builder of railroads and bridges, in addition to being a successful businessman who served as Director of the Fourth National Bank and of the United States Trust Company. He was a friend of Abram Hewitt's, an old ally on the Committee of Seventy of the County Democracy, and a past President of the Chamber of Commerce.

⁴² See New York Times, December 11, 1896.

⁴³ See Walker, Fifty Years, p. 149., who argues that "this initial mistake proved costly to the City in later years when the building of extensions of the subway was undertaken, for the zig-zag line compelled the laying out of a new route on the same plan or the building of north and south wings to the existing road, which of course meant operation by the company which leased the first subway. It is difficult to estimate the time consumed in adjusting the new lines to this situation, but it is safe to say that rapid transit relief was delayed some years in consequence."

⁴⁴ RTC, Report of 1900-1901, pp. 31-36.

⁴⁵ Ibid., p. 36.

⁴⁶ New York Times, October 31, 1897.

⁴⁷ New York Times, November 9, 1897.; New York Times, Editorial, November 12, 1897.

- ⁴⁸RTC, Report of 1900-1901, p. 16.
- ⁴⁹Ibid., pp. 39, 51.
- ⁵⁰Instead of merely \$15 million, the prospective lessee had to provide double security for his bond, that is, raise the sum of \$30 million.
- ⁵¹RTC, Report of 1900-1901, p. 56.
- ⁵²Letter from Newman Erb in New York Times, April 2, 1898. Erb's argument was that the Manhattan Company, with its profits reduced to four percent and its passenger traffic diminishing, could barely afford the necessary electrification of its lines, much less build the extensions and improvements the RTC desired.
- ⁵³As quoted in New York Times, January 1, 1898.
- ⁵⁴Ibid.
- ⁵⁵In October 1897 Abram Hewitt wrote to Cornelius Bliss, a reform-minded Republican, lamenting the decision of the Republican party to nominate its own candidate in the election of November 1897, and warning that the action would only serve to defeat Seth Low and elect the Tammany candidate, Robert Van Wyck. See Hewitt to Cornelius N. Bliss, 18 October 1897, Cooper-Hewitt papers.
- ⁵⁶On the entire question of consolidation, see the excellent analysis of David Hammack, "Participation in Major Decisions," pp. 80-312.
- ⁵⁷RTC, Report of 1900-1901, pp. 40-41.; and McNeil, "Financial History," pp. 56-57.
- ⁵⁸See Walker, Fifty Years, pp. 155-160.; Cheape, "Evolution of Urban Public Transit," pp. 144-148.; Brooks, "History of Street and Rapid Transit Railways," pp. 224-226.; McNeil, "Financial History," pp. 52, 56-57.
- ⁵⁹This was true in the 1880's, when William Grace was twice elected Mayor, again in 1894, when William Strong defeated the Tammany candidate, and again in 1901 when Low was victorious.
- ⁶⁰See Hammack, "Participation in Major Decisions," pp. 420-426.
- ⁶¹As quoted in ibid., p. 425.
- ⁶²Ibid., p. 426., and Buenker, Urban Liberalism, pp. 31-41. "There can be little doubt," writes Buenker, "that the growing popularity of reformers of the Pingree-Johnson-Jones school in the ethnic working class wards was a major factor in the switch made by many urban machines to a more progressive stance. . . . progressive issues were becoming so popular that politicians of both parties ignored them only at their peril." Buenker, Urban Liberalism, p. 31.

- ⁶³ As reported by Bird Coler, Comptroller of New York City, in an interview in the New York Times, January 13, 1900.
- ⁶⁴ As quoted in the New York Times, February 3, 1898.
- ⁶⁵ See the opinion expressed in an editorial in the New York Times, March 16, 1898.
- ⁶⁶ Chamber of Commerce of the State of New York, Fortieth Annual Report of the Corporation of the Chamber of Commerce of the State of New York for the Year 1897-'98 (New York: Press of the Chamber of Commerce, 1898), p. 113 (Hereafter cited as C. of C., Annual Report 1897-98.).
- ⁶⁷ Ibid.
- ⁶⁸ Ibid., p. 112. See also New York Times, March 23, 1898.
- ⁶⁹ RTC, Report of 1900-1901, p. 56.
- ⁷⁰ Ibid., pp. 67-70.
- ⁷¹ Though elected on a Tammany slate, Coler was in fact a reformer. Though restrained by Mayor Van Wyck from too active cooperation with the RTC, he clearly sought to aid it, and he strongly advocated municipal ownership of the proposed subway. And though Mayor Van Wyck, who, with Coler, was an ex officio member of the RTC, never came to its meetings until March 1899, and then only to support the proposals of the Metropolitan Railway to construct a subway with private capital, Coler began attending RTC meetings as early as the Spring of 1898. See New York Times, May 13, 1898, and Editorial, New York Times, July 1, 1899, on Bird S. Coler and Abram S. Mewitt as examples of good men who were nevertheless obliged to "come up" politically through the auspices of Tammany Hall.
- ⁷² All quotations from Orr in the above section are from: Letter, Alexander E. Orr to Edward M. Shepard, 19 May 1899, Shepard Papers.
- ⁷³ New York Times, January 25, 1899.
- ⁷⁴ See New York Times, February 3, 1898 and April 2, 1899. On the first occasion, pushing forward the Manhattan's proposals, Croker said: "The city hasn't the money to build a tunnel. There is only a small margin of credit left to the city. It wouldn't pay for one quarter of the tunnel. Then, again, the tunnel, even if feasible, would take too long. The city hasn't the time or money for tunnels. It must have rapid transit relief and have it at once. Aside from that, the elevated road is a better scheme. Wouldn't a man rather ride in the open air than underground?"
- On the second occasion, supporting the Metropolitan's proposal to build the subway with private capital, Croker said: "I can only say . . . that I am in favor of rapid transit, and that I believe in the underground road, but the condition of the city's finances is such that it could not undertake its construction at this time; consequently private capital must be employed for the project."
- ⁷⁵ For W.C. Whitney's and the Metropolitan's relation to Tammany, see Hendrick, "Great American Fortunes," p. 44.; and Mirsch, Whitney,

- pp. 225-226, 424-426. For the relation of the Manhattan to Tammany, see New York Times, December 7, 1897. At the beginning of 1899, Croker and George Gould quarreled. Croker was part owner of a firm, the Auto-Truck Supply Company, which made compressed air pipes. He offered to supply these to the Manhattan Company in return for his support with the RTC in favor of the Manhattan's meagre proposals for extensions of its lines. At first the Manhattan seems to have gone along with this deal, for in early February 1898 Russell Sage announced that the company was considering changing its motive power from steam to either electricity or compressed air, and Sage had much to say in favor of compressed air. A year later, however, the Manhattan decided definitively in favor of electricity, whereupon Croker broke with the company and ordered city officials to harass it over petty infractions of rapid transit regulations. This, at any rate, is the story conventionally invoked to explain Croker's break with the Manhattan. Perhaps more important than these petty considerations, however, was the fact that Croker, like everyone else, realized that the Manhattan would never give the city rapid transit, and that, considering the state of public opinion on this question, the survival of his "machine" depended on its providing the city with an underground railway. For the story of Croker, Gould, Sage, and the Auto-Truck Company, see New York Times, February 3, 1898., February 2, 7, 26, 1899.
- ⁷⁶RTC, Report of 1900-1901, pp. 26-27.; New York Times, March 24, 1897.
- ⁷⁷RTC, Report of 1900-1901, p. 45.
- ⁷⁸See New York Times, January 15, 16, 1898; February 2, 1899.
- ⁷⁹RTC, Report of 1900-1901, p. 52.
- ⁸⁰On Parsons' Chinese railway scheme, see: Letter, William Barclay Parsons to Seth Low, 9 May 1900, Seth Low Papers, Manuscript Collection, Columbia University.
- ⁸¹Parsons to Shepard, 15 October 1898, Shepard Papers.
- ⁸²All quotations from: Letter, Parsons to Shepard, 26 February 1899, Shepard Papers.
- ⁸³These were the justifications made for the Metropolitan offer by the RTC, as quoted in the New York Times, March 20, 1899.
- ⁸⁴On December 23, 1898 the Times reported that the RTC was considering the proposal of a bill whereby the subway, once built, could sell surplus light, heat, and power as a source "of immense revenue." This was a prelude to the Metropolitan deal. On the terms of the Metropolitan deal, see New York Times, March 28, 1899.
- ⁸⁵A.E. Orr, as quoted in New York Times, March 30, 1899.
- ⁸⁶The provision for a five cents fare was carried over from the Rapid Transit Act of 1891. The Charter of the City of New York prohibited the granting of franchises for the use of its streets for a period longer than twenty-five years. See RTC, Report of 1900-1901, p. 62.

- ⁸⁷ See New York Times, April 3-13, 1899.
- ⁸⁸ As quoted in New York Times, April 3, 1899.
- ⁸⁹ New York Times, March 28, 1899. Mayor Van Wyck only began attending meetings of the RTC on the day the Metropolitan deal was announced.
- ⁹⁰ For Bird Coler's views, see New York Times, April 1, 1899 and April 6, 1899. For the views of Louis Haffen, Bronx Borough President, and Timothy Woodruff, President of the New York State Senate, see New York Times, April 13, 1899. For mass meeting at Cooper Union attended by, among others, R. Fulton Cutting, Felix Adler, Charles Eaton, Andrew H. Green, E.V. Grout, Carl Schurz, and W.J. Gaynor, see New York Times, April 12, 1899.
- ⁹¹ For full exposition of the interchange between Governor Roosevelt and the RTC, see New York Times, April 19, 1899.
- ⁹² Theodore Roosevelt to Henry Cabot Lodge, 9 April 1900, as quoted in Hirsch, Whitney, pp. 515-516.
- ⁹³ See R.R. Bowker, "The Piracy of Public Franchises," Municipal Affairs, V, 4 (December 1901), 890-904.
- ⁹⁴ See New York Times, April 18, 1899.
- ⁹⁵ RTC, Report of 1900-1901, p. 73.

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- ¹ Chamber of Commerce of the State of New York, Rapid Transit in New York City and in Other Great Cities (New York: Press of the Chamber of Commerce, 1905), pp. 196-252.
- ² RTC, Report of 1900-1901, p. 78. The city was to provide the contractor with money -- up to 1.75 million dollars to purchase real estate for terminals and up to \$1 million for other real estate.
- ³ Ibid., p. 20.
- ⁴ See McNeil, "Financial History," pp. 80-82.; Latta, "The Return on the Investment in the IRT," pp. 8, 12.; and New York Times, November 14, 1899 and November 29, 1899, where it was argued that the underground road would "pay," and that profit from construction would be about \$8 million, or sufficient funds for the contractor to finance equipment from the profits of construction. See also testimony of August Belmont in Record on Appeal in Continental Securities Company v. August Belmont, 168 App. Div. 483 (1915), I, 344 (Hereafter cited as Record on Appeal, 168 App. Div. 483). In a typescript found among the personal papers of August Belmont (II), the President of the IRT says that "the dividends paid by the Interborough from its inception to the present (1921?) time average less than 10% per annum." August Belmont II Papers, private collection of August Belmont IV, Easton, Maryland (hereafter referred to as "private Belmont collection").

- 5 William C. Whitney thought that without a perpetual franchise the subway would at best yield a return of 3%. The Progressive journal, Outlook, estimated the return at 7%. See Hirsch, Whitney, p. 521.
- 6 For this formula, see the testimony of August Belmont in New York State, Minutes and Testimony of the Joint Legislative Committee Appointed to Investigate the Public Service Commission (Albany, 1916), VI, 545-546.
- 7 For a review of these criticisms, see Cheape, "Evolution of Urban Public Transit," pp. 159-173.
- 8 New York City, Board of Rapid Transit Railroad Commissioners, Contract for Construction and Operation of Rapid Transit Railroad, February 21st, 1900 (New York, 1900), pp. 44-45 (Hereafter cited as RTC, Contract No. 1).
- 9 Ibid., pp. 167-175, 213-217.
- 10 Ibid., pp. 17, 175, 177.
- 11 Ibid., pp. 16, 473-495.; pp. 6, 10, 20.
- 12 Ibid., pp. 171-173.
- 13 Ibid., pp. 12-16, 213-217, 473-495.
- 14 See Parsons' remarks on Baltimore tunnel in his testimony before the Committee of the General Term of the Supreme Court of New York, in the New York Times, December 20, 1895.
- 15 New York Times, January 18, 1900.
- 16 New York Times, January 16, 1900.
- 17 New York Times, January 18, 1900.
- 18 New York Times, January 16, 1900.
- 19 New York Times, January 16, 1900.
- 20 New York Herald, January 16, 1900.
- 21 In his letter to A.E. Orr, President of the RTC, Whitney disclaimed any "connection or responsibility for either bid." It is fair to say, however, that he protested rather too loudly. This is especially true since, two weeks later, in response to an appeal from the brother of one J.S. Crabbe, seeking work in subway construction, he had his secretary say, in a disgruntled tone, that "the rapid transit work . . . has been undertaken by capitalists with whom Mr. Whitney is not identified." This was of course after Belmont and McDonald had been awarded the contract and had bypassed the recalcitrant surety companies by forming a construction company of their own. Letters; W.C. Whitney to A.E. Orr, 16 January 1900, and W.C. Whitney to J.S. Crabbe, 29 January 1900, in William C. Whitney Letterbooks, VIII (September 20, 1899 - January 30, 1900), Manuscript Division, Library of Congress. See also the partial copy of Whitney's letter

to Orr, in New York Times, January 18, 1900.

- 22 For this presumption, see New York Times, February 8, 1900.; and "The Reminiscences of John T. Hettrick," pp. 79, in the Oral History Collection, Manuscript Collection, Columbia University (Hereafter cited as "Hettrick," OHC).
- 23 New York Times, January 28, 30, 31, 1900; February 1,2,3,4,6, 1900.
- 24 See testimony of Andrew Freedman, Record on Appeal, 168 App. Div. 483, II, 594-617.; and testimony of August Belmont, Record on Appeal, 168 App. Div. 483, I, 305-320.; "Hettrick," pp. 78-85, OHC. For Belmont's biography, see also Hendricks, "Great American Fortunes," p. 332.; and Belmont's obituary in the New York Times, December 11, 1924.
- 25 New York Times, January 30, 1900.
- 26 Perry Belmont, An American Democrat: The Recollections of Perry Belmont (New York: Columbia University Press, 1940), pp. 460-463.
- 27 "Hettrick," p. 82, OHC.
- 28 RTC, Report of 1900-1901, p. 75.; "Hettrick," p. 81, OHC.
- 29 "Hettrick," p. 82, OHC.; Testimony of August Belmont, Record on Appeal, 168 App. Div. 483, I, 319.
- 30 Remarks made by August Belmont IV, grandson of the traction magnate, to the author of this report.
- 31 Letter, Parsons to Seth Low, 9 May 1900, Low Papers, in which Parsons speaks of the financial backing for his Chinese railway scheme. August Belmont II is listed prominently as a director.
- 32 August Belmont IV, in remarks to the author of this report, claims that with respect to the Cape Cod Canal venture, as with the IRT, Parsons was the guiding spirit. For more on the Cape Cod Canal and the role of Belmont and Parsons, see Belmont Papers, Massachusetts Historical Society, on microfilm at the New York Historical Society.
- 33 P. Belmont, An American Democrat, pp. 460-463.
- 34 Ibid. Perry Belmont implies that this was actually the case.
- 35 Letters; August Belmont II to E.H. Harriman, 19 April 1894; Belmont to Stuyvesant Fish, 18 April 1894, 4 April 1899; Belmont to John W. Inman, 10 May 1895, Private Belmont Collection. On May 10, 1895 Belmont wrote John Inman to the effect that he (Belmont), Fish, and Harriman were reorganizing the Chesapeake, Ohio, and Southwestern Railroad, and that the Illinois Central and the Louisville and Nashville were jointly acquiring control of the Chesapeake. Belmont also served with Harriman, Anthony Brady, and H.H. Porter on the board of the Brooklyn Rapid Transit Company, after the latter took control of Belmont's King's County Elevated in 1899. See New York Times, January 28, 1900.

- 36 See Vincent F. Seyfried, The Long Island Railroad, A Comprehensive History (Garden City, Long Island: Doubleday, 1961), Ch. I.
- 37 Letters; Belmont to Walter G. Oakman, 29 April 1899; Belmont to General James Jourdan, 14 March 1899, Private Belmont Collection.
- 38 New York Times, August 23, 1899 and January 28, 1900.
- 39 New York Times, August 23, 1899.
- 40 The only book on Belmont's father, August Belmont I, is Irving Kats, August Belmont, A Political Biography (New York: Columbia University Press, 1968). According to August Belmont IV, David Black is now preparing a comprehensive history of the Belmont family and its role in American business, politics, and society.
- 41 Letter, Belmont to Richard Croker, 28 March 1893, Private Belmont Collection, about horse racing.
- 42 New York Times, January 17, 1900.
- 43 New York Times, January 16, 1900.
- 44 Ibid.
- 45 See Hendrick, "Great American Fortunes," p. 332.; and obituaries of August Belmont II in New York Times, World, and Herald Tribune, December 11, 1924.
- 46 Belmont was elected to the Chamber of Commerce in 1891. When the new headquarters of the Chamber was completed in 1 , the Times gave over several pages in its Sunday rotogravure to the building, and pictured Belmont, along with A.E. Orr, J.P. Morgan, Cornelius Vanderbilt, Abram Hewitt, John D. Crimmins, and others as prominent members of the organization. See New York Times,
- 47 New York Times, January 16, 1900.
- 48 New York Times, January 16, 1900.
- 49 RTC, Report of 1900-1901, pp. 73-74.
- 50 New York Times, January 16, 1900.
- 51 Whitney to A.E. Orr, 16 January 1900, Whitney Papers.
- 52 McDonald, as quoted in New York Times, January 16, 1900.
- 53 See Record on Appeal, 168 App. Div. 483, I, 305-320, II, 594-617.; and New York State, Minutes and Testimony of the Joint Legislative Appointed to Investigate the Public Service Commission (Albany, 1916), VI, 545-546.
- 54 See the rapid transit plank in the Tammany platform during the campaign of Fall 1897, New York Times, October 1, 1897.

- 55 New York Times, January 26, 1900.
- 56 "Agreement of 20 January 1900 between John B. McDonald and August Belmont and Company, relating to deposit of \$1,000,000 against damages and bid deposit of \$150,000." Part of contents of Box marked "Documents," in possession of Rapid Transit Subway Construction Company, courtesy of Hugh Dunne.
- 57 See New York Times, January 30, 1900.
- 58 See Hirsch, Whitney, p. 521.; and Hendrick, "Great American Fortunes," p. 332.
- 59 Whitney to A.E. Orr, 16 January 1900, Whitney Papers.
- 60 The matter was not even tentatively settled until January 30, 1900, or some two weeks after McDonald was awarded the contract, and the Rapid Transit Subway Construction Company was not formed until February 19, 1900. See New York Times, January 30, February 6, 1900.
- 61 New York City, Board of Rapid Transit Railroad Commissioner, Minutes of Proceedings of the Board of Rapid Transit Railroad Commissioners 1899-1901 (New York, 1902), pp. 884, 887-888, 891-893 (Hereafter cited as RTC, Proceedings 1899-1901).
- 62 Ibid.
- 63 McNeil, "Financial History," pp. 76-77.; "List of Stockholders of the Rapid Transit Subway Construction Company," Part of contents of Box marked "Documents," in possession of Rapid Transit Subway Construction Company, courtesy of Hugh Dunne.
- 64 RTC, Report of 1900-1901, p. 75.
- 65 McNeil, "Financial History," pp. 75-76.; RTC, Contract No. 1, pp. 213-217, 473-495.
- 66 McNeil, "Financial History," p. 76.; RTC, Contract No. 1, pp. 274-279. Agreement concerning Continuing Bond of \$1,000,000 signed by John B. McDonald and Perry Belmont, 20 February 1900, Part of contents of Box marked "Documents," in possession of Rapid Transit Subway Construction Company, courtesy of Hugh Dunne.
- 67 Latta, "The Return on the Investment in the IRT," p. 21.; "Agreement of February 21, 1900 between John B. McDonald and the Rapid Transit Subway Construction Company," Part of contents of Box marked "Documents," in possession of Rapid Transit Subway Construction Company, courtesy of Hugh Dunne.
- 68 RTC, Proceedings 1899-1901, pp. 891-893, 907.
- 69 McNeil, "Financial History," pp. 80-82.; and testimony of August Belmont, Record on Appeal, 168 App. Div. 483, I, 308, 354. The city paid out \$34.5 million for the subway; the Rapid Transit Subway Construction Company expended \$23,822,915 for subcontractors and almost \$5 million for management and administration, or \$27.5 million, leaving \$6.5 million and 10% of \$4.3 million in extra work. Belmont

testified to the following in regard to the profit from subway construction: "The Interborough Company was organized in 1902 with a capital stock of \$35,000,000. By this time all of the sub-contracts had been let and it was estimated that there would be a profit in construction, based on McDonald's bid of \$35,000,000., of approximately \$8,000,000. to which the Rapid Transit Subway Construction stockholders are justly entitled. Their obligation, however, was not alone to construct the road, but also to equip and operate it, and in voting them this prospective profit it was done in Interborough stock so as to compel them to assume the additional risk of operation. At the same time I was voted 15,000 shares of Interborough stock for the services of myself and firm in bonding the contractor to the extent of \$6,000,000., as reimbursement for the purchase of the City Island Railroads and for promoting the subway and underwriting the contract. The stock at that time had only a contingent value and as a matter of fact the actual profit on the subway dwindled to a little over \$2,000,000. and this moment is still in possession of the city." See also Typescript of testimony of August Belmont in *Continental Securities v. August Belmont*, Belmont Private Collection.

⁷⁰ See Ray Stannard Baker, "The Subway Deal: How New York City Built its New Underground Railroad," McClure's Magazine, XXIV, 5 (March 1905), 467.; and Edward M. Grout to Andrew H. Green, 10 May 1902, as quoted in New York Times, February 17, 1903.

⁷¹ Latta, "The Return on the Investment in the IRT," pp. 32-33.

⁷² New York Tribune, March 20, April 13, 17, 18, 1901.; Hirsch, Whitney, p. 522. Hirsch believes that Whitney finally enabled Belmont to get his company chartered out of "good sportsmanship" or in order to lay an "artful trap" which would later incline Belmont to a deal for a merger with the Metropolitan. But Hirsch ignores the importance of the purchase of the City Island and Pelham Park railways. Since Belmont already owned these and could have used them to incorporate his operating company, Whitney's game was over and his refusal of Belmont's request for help with the legislature in obtaining a charter would have accomplished nothing.

⁷³ Baker, "Subway Deal," pp. 461-462.

⁷⁴ Testimony of August Belmont, Record on Appeal, 168 App. Div. 483, I, 302, 483-500.

⁷⁵ Testimony of August Belmont, Record on Appeal, 168 App. Div. 483, I, 488-503.

⁷⁶ Ibid.; Walker, Fifty Years, pp. 169-171.; New York Times, July 9, 1912.

⁷⁷ New York City, Board of Estimate and Apportionment, Report Covering Investigation into the Transit Situation in the City of New York -- Interborough Rapid Transit Railroad Company (Contracts Nos. 1, 2, and 3) and the New York Railroad Company (New York, May 20, 1921), p. 3007. (Hereafter cited as Report into the Transit Situation).

⁷⁸ Ibid., pp. 3006-3007.; Latta, "The Return on the Investment in the IRT," pp. 37-41.; McNeil, "Financial History," pp. 93-96. Testimony

- of August Belmont, Record on Appeal, 168 App. Div. 483, I, 488-503.
- ⁷⁹ See Baker, "Subway Deal," p. 469.; Report into the Transit Situation, p. 3007. The latter document describes Rapid Transit Subway Construction Company stock, paid in at 60%, as being exchanged for IRT stock at 160% of par. It also describes the 15,000 shares of IRT stock given to Belmont as "representing the practically worthless franchises of the City Island and Pelham Park Railways."
- ⁸⁰ Continental Securities Company and Clarence H. Venner v. August Belmont and Others, 168 App. Div. 483 (N.Y. 1915).
- ⁸¹ "Plaintiff's Exhibit 19" of the Record on Appeal, 168 App. Div. 483, III, 73-74.; Latta, "The Return on the Investment in the IRT," p. 35. The figure of \$3.9 million is equivalent to the \$3.6 million paid into the Rapid Transit Subway Construction Company and transferred to the IRT, plus the value of the City Island and Pelham Parkway Railroads at approximately \$300,000.
- ⁸² Typescript of August Belmont's remarks at dinner at Sherry's Restaurant, 27 October 1904, in honor of the opening of the IRT, Volume I of Belmont Collection of typescripts and newspaper clippings; Museum of the City of New York (Hereafter cited as "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York).
- ⁸³ New York State, Report of the Public Service Commission for the First District of the State of New York for the Year Ending December 31, 1910 (Albany, 1911), III, 163.; and McNeil, "Financial History," pp. 98-99.
- ⁸⁴ RTC, Proceedings 1899-1901, pp. 1083, 1126.
- ⁸⁵ Baker, "Subway Deal," pp. 464-465.
- ⁸⁶ New York City, Board of Rapid Transit Railroad Commissioners, Minutes and Proceedings of the Board of Rapid Transit Railroad Commissioners 1902 (New York, 1903), pp. 1675-1692.
- ⁸⁷ Ibid., pp. 1704-1705.
- ⁸⁸ McNeil, "Financial History," pp. 102-103.
- ⁸⁹ Report of the P.S.C. 1913, V, 535.; Report into the Transit Situation, pp. 3007-3008.; McNeil, "Financial History," pp. 101-110.

EPILOGUE

- ¹ See especially the letter of Edward Grout to Andrew H. Green of May 10, 1902, as quoted in New York Times, February 17, 1903. See also New York Citizen's Union, Bureau of City Betterment, Suggestions for Improvement of City Transit, February 1903 (New York, 1903); New York City Merchants Association, Passenger Transportation Service in the City of New York, September 1903 (New York, 1903); Municipal Arts Society: Committee on City Plan, Bulletin, No. 3 (1903). Two slightly

later but important criticisms in the same vein were: Samuel Seabury, Municipal Ownership and Operation of Public Utilities in New York City (New York, 1905); and New York Board of Trade and Transportation, Passenger Transportation Franchises and their Control: Report by the Executive Committee of the New York Board of Trade and Transportation, Adopted by the Board, September 27, 1905 (New York, 1905).

²For a critical but not unfair description of the RTC, see Baker, "Subway Deal," p. 463.

³Typescript remarks of Jacob Schiff, "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York.

⁴Ibid.

⁵Ibid.

⁶Typescript remarks of A.E. Orr, "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York.

⁷Baker, "Subway Deal," p. 463.

⁸Hendrick, "Great American Fortunes," p. 332.

⁹Ibid.

¹⁰Remark made by August Belmont IV to the author of this report.

¹¹For the IRT-Metropolitan merger, see Hirsch, Whitney, pp. 522-524.; and Hendrick, "Great American Fortunes," pp. 334-336.

¹²Remarks of August Belmont, "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York.

¹³Remarks of William Barclay Parsons, "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York.

¹⁴Remarks of Morris Jessup, "Sherry's," Vol. I, Belmont Collection, Museum of the City of New York.

¹⁵Baker, "Subway Deal," p. 464.

¹⁶Grout to Green, May 10, 1902, as cited in New York Times, February 17, 1903.

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HISTORIC AMERICAN ENGINEERING RECORD
INTERBOROUGH RAPID TRANSIT SUBWAY (ORIGINAL LINE)

NY-122

"THE IMPACT OF THE IRT ON NEW YORK CITY"

Location:	New York City, New York UTM: (Indeterminable) Quad: Brooklyn, Central Park
Date of Construction:	1900-1904
Present Owner:	City of New York
Significance:	The IRT was New York City's first subway.
Historian:	Clifton Hood, 1978.

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The day after the IRT opened on October 27, 1904, the New York Tribune announced the "birth of (the) subway crush."¹ New Yorkers welcomed the subway eagerly at first. Hundreds of thousands waited in lines as long as two city blocks for an opportunity to play with the "new toy." But the enthusiasm quickly ended because of overcrowding. Train after train moved along the line, but the crowds never diminished. The cars were packed to the limit, and station platforms were congested.² "In shore," the Real Estate Record and Builders Guide said on November 5, "the subway should have been designed to handle much larger crowds than existing stations and their approaches can accommodate."³ During the next decade, the overcrowding of the IRT argued strongly for the development of additional transit facilities in New York.

The Rapid Transit Commission and the Belmont interests expected the subway to bear heavy traffic loads. Transit experts knew the introduction of a rapid transit railway into an expanding city often did not free the existing lines of congestion. New lines not only drew passengers from old lines but also created their own traffic. By making travel faster and more convenient than before, new railways generated more passenger traffic than they could comfortably carry.⁴ In 1905, the Street Railway Journal said:

One of the most interesting features of opening new rapid transit lines for service in the densely populated districts of large cities is the effect of these additional facilities upon the volume of traffic within the tributary region. It has long been recognized that a permanent solution of the rapid transit problem in a growing city cannot be secured by the development of a single route of high speed service. New facilities not only open up additional avenues of travel and thereby can -- and often do -- relieve congestion existing upon other lines; they apparently create traffic, which sooner or later grows to a volume that requires additional means of transportation to be furnished.⁵

The Rapid Transit Commission intended to construct more rapid transit lines eventually, but in 1900 the one subway under construction was the most the city could afford. The Board hoped it would suffice to relieve transit congestion temporarily.

The subway traffic was greater than anticipated. Frank Hedley, general manager of the Interborough Rapid Transit Company, said in October 1904 that the subway was designed for a maximum daily capacity of 600,000 passengers. According to Daniel L. Turner, an assistant engineer for the Rapid Transit Commission during the IRT construction, the subway builders originally

planned on a maximum capacity of 400,000 riders per day. These estimates notwithstanding, most observers agreed that the patronage in 1904 was too great. In December 1904 the IRT averaged 300,000 passengers each day. There was little margin for growth. On the first anniversary of the completion of the subway, the Interborough announced that the line was nearing its limit. By opening new stations, modifying technical features, and altering existing stations, the Interborough managed to pack more people underground. The daily passenger traffic surpassed the 800,000 mark in 1908 and reached 1.2 million six years later.⁶ "Although the present subway is now carrying more passengers than it was originally designed to carry," Bion J. Arnold, a consulting engineer, reported in 1908, "the number of patrons is increasing yearly and the maximum carrying capacity is therefore taxed to the utmost limit."⁷

The subway failed to provide the expected relief for the congested surface and elevated railways. In Street and Electric Railways, 1902, the Bureau of the Census predicted that once the subway opened "a great relief will be afforded to overcrowded elevated lines and to the thousands of long-distance passengers who now take the surface cars."⁸ In fact, the elevated and surface lines remained crowded after 1904. The patronage of the IRT elevated division declined for several years after 1904, but in 1907 the elevated roads carried only one percent fewer patrons than in 1904. Between 1904 and 1910 the surface railways transported an average of 372.5 million passengers, four percent less than the 1904 total.⁹ In 1907 General Manager Frank Hedley said that,

The traffic situation throughout New York when the New York subway was opened was simply a question of calculation, a matter of opinion, as to how many passengers the elevated roads would carry after the subway opened. The subway was opened, and we carried large numbers of people down there. The business on the elevated has not fallen off to the extent that was expected. . . .¹⁰

One reason for the unanticipated IRT traffic was the electrification of the surface railways and elevated roads that took place before and after subway construction had begun. In the United States, the total amount of all street railway trackage that was operated with electric power increased from 15.5 percent in 1890 to 97 percent in 1902. "Following the successful electrification of the Lenox Avenue line in the mid-1890s, New York traction magnates began to convert their cable and horse lines to electricity. The Metropolitan electrified surface lines such as Second Avenue, Madison Avenue, and Columbus Avenue. By 1902, 134 miles of the 197 single-track miles in the Metropolitan system were electric powered. The heavy overhead costs of

cable railways restricted street car operation to crowded urban areas, while the low operational costs of electric railways permitted the expansion of routes. Because electric street cars, when unhampered by street congestion, traveled more than three times faster than horse cars, companies were able to extend their lines into undeveloped areas. The extension of roads stimulated residential development which in turn increased street railway patronage.¹² In addition, the speed of the electric cars enabled companies to gain passengers within established areas. H.H. Vreeland, president of the Metropolitan wrote in 1900 that electrifying the Madison Avenue horse car line reduced traveling time by one-third and nearly tripled patronage. Between 1890 and 1903, the total number of surface railway passengers in Manhattan grew from 215.2 to 382.2 million.¹³

Competition from the electric street railways nearly ruined the Manhattan Elevated Railway Company during the 1890s. Its steam driven elevated cars were not only slower and smaller than the electric cars but also less comfortable and reliable. The patronage of the Manhattan Railway Company totaled 191.1 million in 1901, a decline of 28 million since 1893.¹⁴

The conversion to electrical power reversed the fortunes of the Manhattan Railway Company. Only three years after the switch to electricity began in 1901, the elevated roads carried 50 percent more riders than before. Because the street congestion that delayed surface cars did not hinder rapid transit lines, electric cars ran more quickly on elevated roads. The Manhattan Railway Company thus gained passengers at the expense of the surface roads. But even though the patronage of street lines grew at a much slower rate after 1901, it did not decrease. From 1901 to 1903, the surface traffic in Manhattan increased by more than five percent.¹⁵

The electrification of the elevated stimulated a general increase in railway traffic. The elevated and surface lines in Manhattan carried one-fifth more people in 1904 than in 1901. This increase was mainly due to the greater frequency with which residents and workers traveled. In Manhattan, the Bronx, and Queens, each resident took an average of 274 trips on the elevated and street railways in 1904, compared to 248 rides in 1900.¹⁶ By 1902 the transit lines in Manhattan were crowded to capacity. That year the Street Railway Journal reported that,

. . . in New York it seems impossible to keep up with the growth of the city. The elevated and surface lines are operating as many cars as can be accommodated. Every evening during the rush hour, the cars on the principal surface lines run so closely together that there is reason for complaint on the part of pedestrians who are unable to proceed east or west without experiencing much delay and vexation. On the elevated, it is not unusual to see three five-car north-bound trains on the curve at 110th Street. This is about the limit of the present facilities.¹⁷

The electrification of the elevated lines made obsolete the traffic projections of the subway builders. It was apparent by 1902 that the subway, designed before the advent of electrical power on the elevated, would be incapable of handling the increased traffic. William Barclay Parsons, chief engineer of the Rapid Transit Commission, wrote in February 1903 that "Tremendous increase in passenger travel on all lines during the past year clearly indicates that when the present subway system now under construction from Brooklyn to the Bronx is completed . . . it will almost be immediately congested . . ."18

In 1902 and 1903 the Rapid Transit Commission prepared its plan for the further development of underground and elevated railways. This plan, known as the comprehensive plan, was both the outgrowth of longstanding Commission policies and also a response to the immediate demand for additional facilities.

From 1895 the Rapid Transit Commission conceived of the original subway as the first in a series of rapid transit lines. The only remedy for traffic congestion, the subway planners believed, was the construction of a well-coordinated railway system. The initial subway proposal in 1895 had envisioned additional subway routes on the east and west sides. The plan was abandoned because of the municipal debt limit and the adverse decision of the New York State Supreme Court.

The consolidation of New York City in 1898 and the successful construction of the IRT made possible the enlargement of the system. Transit expansion became essential once the elevated's electrification resulted in the rapid growth of passenger traffic.¹⁹ One year after the electrification began in 1901, the Rapid Transit Commission reported that:

In no other city has the burden of intra-urban railway traffic reached the proportions existing in New York . . . The present facilities were designed to carry a much smaller number, and, in consequence, all of the present lines are seriously overtaxed. Great as is the present burden of traffic, the coming years will show larger totals . . . Whatever additions to or extensions of the present railway system are made, should be made on a comprehensive plan, looking not only to the urgent needs of the present day, but the still more urgent needs that will arise in the future.²⁰

The Commission wanted to build new facilities because the rising traffic levels would prevent the subway from providing even temporary relief for transit congestion. In February 1903, William Barclay Parsons, author of the comprehensive plan said that the IRT was merely a stop-gap solution to the traffic problem, arguing that in order to meet the growing and imperative demands for increased facilities, arising from the natural growth of our city, it is evident that new lines should be laid down as soon as possible . . ."21

The comprehensive plan called for development on a large scale. In Manhattan and the Bronx, Parsons recommended the construction of two subways intended to complete the IRT line by providing connections to the lower west and upper east sides: one from the Forty-Second Street IRT station to South Ferry, and the second north along Lexington Avenue from a junction with the IRT at Fortieth Street and Park Avenue to Mott Haven. Parsons also wanted cross-town subways built on Thirty-Second and One Hundred Tenth Streets. From the terminus of the Brooklyn extension at the intersection of Flatbush and Atlantic Avenues, Parsons laid out a four-track route beneath Flatbush Avenue to Prospect Park Plaza. Two branch lines extended beyond the park; a two track line into the Flatbush district and a three-track subway to Brownsville. Another route went south from the Borough Hall IRT station under Fourth Avenue toward Fort Hamilton. Parsons also suggested improvements for the elevated systems. In order to increase express service, Parsons recommended the construction of addition tracks on existing lines. The Brooklyn Rapid Transit Company, for instance, was only able to operate local trains because of all its routes were double-tracked. He also proposed the extension of the elevated roads in Brooklyn, Queens, and the Bronx. For more than ten years, however, the building of new transit facilities was delayed because of disputes that arose about the original subway.²²

The second cause for the overcrowding of the IRT was its innovative express service. Because the IRT was the first subway with separate double-tracks for running express trains, there was no reliable means of gauging its impact.²³ At the time the subway was designed, the Rapid Transit Commission and particularly the Belmont interests feared that express service might not be profitable. They thought that local trains would carry the bulk of the passengers, and initially restricted express service to the developed areas of Manhattan. The construction plan laid out two tracks beyond Ninety-Sixth Street for local trains, but express service was to terminate at the junction of the Broadway and Lenox Avenue branches. The decision made to add a third track for express service north of Ninety-Sixth Street was in part a response to the traffic increases caused by the electrification of the elevated.²⁴

Some of the Manhattan elevated lines operated express trains, but their service was not complete enough to provide the subway planners with a basis for accurate forecasts. No elevated ran expresses along its entire route. The Ninth Avenue line, for instance, went from Cortlandt Street to the Harlem River in 1902, but expresses only ran between Fourteenth and One Hundred Sixteenth Streets. Less than one-half of the total length of the Manhattan Railway system was served by express trains in 1900. Because the elevateds employed one track for express service instead of two, moreover, the trains proceeded one way at a time. They headed south toward the business district during the morning rush hour, and north at night.²⁵ The subway express service was a major improvement over the elevated. "The

striking feature about the subway, which is about to be completed," William Barclay Parsons said in early October 1904, "is its completeness and the fact that it offers a double service for both express and local travel, in which respect it is far in advance of any similar line hitherto undertaken."²⁶

The IRT express service was more popular than expected. Contrary to the original estimates, expresses carried more passengers than locals. The express trains, which ran one-third faster than locals when not delayed, broke down transportation barriers to the outward expansion of the city. People were able to move further from the city core but remain within the same traveling time from their work places. The vast amount of residential construction the subway stimulated in outlying areas also added to the express traffic.²⁷

The introduction of express service also slowed train operations. Because large numbers of passengers transferred between express and local cars, the trains were kept at the stations over schedule. These delays contributed to the traffic congestion since the running of fewer trains reduced the carrying capacity of the subway.²⁸ In his address to the British Institution of Civil Engineers in 1908, Parsons said:

The transfer from one service to another has been not only to exceed estimates, but to occur to such an extent as to seriously delay express trains. By far the greater burden of traffic falls on express trains, whose cars are often crowded to the limit while the local trains contain empty seats.²⁹

The opening of the IRT altered traffic patterns in New York. In the developed sections of Manhattan, surface railways lost long-distance passengers to the faster elevated and underground trains. Although electric street cars were able to attain speeds above 12 miles per hour for brief periods, the street congestion and the frequency of stops reduced their average rates to about eight miles per hour.³⁰ Even slower speeds were maintained by the horse railways, which remained in operation until World War I. In contrast, the elevated trains ran at an average speed of about 14 miles per hour. The Interborough Company scheduled express trains at 25 miles per hour and local trains at 15 miles per hour. The trains usually operated on time for most of the day, but during the peak periods their speeds were reduced to about 13 miles per hour for locals and 18 miles per hour for expresses. The IRT express trains were the fastest form of urban transportation in New York City.³¹

Following the electrification of the elevated roads and the opening of the IRT, the surface railways in Manhattan became principally short-distance carriers. "On some of the surface lines paralleling the subway there is a noticeable falling off in traffic," the Street Railway Journal reported in November 1904, "while even on lines remote from the tunnel the effect is apparent of the better service the tunnel affords."³²

In order to compensate for these traffic losses, the street railway companies curtailed the number of cars in service on some routes running from north to south. The City Club of New York published a report in 1907, entitled New York City Transit, that compared traffic counts made on December 29, 1902 and June 17, 1907 during the evening rush hour on the Lexington and Madison Avenue lines. It revealed a reduction since 1902 of more than 50 percent on each line in the number of northbound cars passing Forty-Fifth Street. This decline was too great to be representative of all routes, but other surface lines also lost traffic. The City Club found, for instance, that in 1907 nine percent fewer cars ran through Herald Square during the rush hour than in 1903. This reduction helped to alleviate vehicular congestion, but the cars were still crowded with riders.³³ In his 1905 pamphlet City Transit Evils: Their Causes and Cure, Charles M. Higgins wrote that surface cars were still "crowded and jammed with passengers, inside and out, not like cattle cars, as this would not be allowed by law in a car of cattle, pigs, or sheep, but more like a basket of fish or other dead freight."³⁴

The subway stimulated the growth of railway traffic in outlying districts. Anticipating the residential development of the Bronx, companies such as Union Railway improved service on existing lines and also built new lines to provide connections with the IRT. From 1900 to 1910 the total length of surface track in the Bronx nearly doubled to about 180 miles.³⁵ "The railway lines in the borough of the Bronx," the Street Railway Journal said in 1906, "were laid out primarily as feeders to the elevated roads and the subway . . ." ³⁶ During the decade that followed the completion of the IRT in 1904, the total street railway traffic in the Bronx increased 129 percent from 34.7 million to 79.6 million riders. The railways continued to carry large numbers of passengers to the subway stations, but the local traffic became increasingly significant as the borough grew. The development of residential and business districts multiplied the amount of traffic.³⁷

The subway also affected traffic within Brooklyn. Because the transit system in Brooklyn, like Manhattan, was far more developed than in the Bronx, the redistribution of traffic was of greater consequence than the expansion of transit facilities.³⁸ When the Brooklyn extension opened in January 1908, the elevated and surface railways that terminated at the Brooklyn Bridge and the East River ferry depots sustained traffic losses. Instead of commuting to Manhattan by way of the ferries and the bridge, many Brooklyn residents took the IRT. In anticipation of the demand for transport to the Borough Hall subway stop, the Brooklyn Rapid Transit Company put 150 more cars into service on routes such as Fulton Street and Flushing Avenue.³⁹ Calderwood, vice-president of the Brooklyn Rapid Transit Company, commented that:

Some (surface) lines which it is believed would be affected, such as Gates Avenue, Fulton Street, and Putnam Avenue, showed increased receipts, while the

Graham and Flushing Avenue lines, which do not provide direct service to Borough Hall, seem to be otherwise affected. This is possibly a result of people traveling to and from the Eastern District adopting entirely new routes.⁴⁰

By creating a new center of distribution, the IRT changed Brooklyn's traffic flow, and bypassed some distant lines.

Beginning in the early 1900s, the passenger traffic on the surface and elevated lines grew rapidly in Brooklyn. The subway played a major role in expanding the traffic, but the completion of the Manhattan and Williamsburg Bridges and the construction of the Long Island Railroad Tunnel were also important developments. In order to meet the increased demand for transportation to the subway stations, the Brooklyn Rapid Transit Company made improvements on the feeder lines. On the Putnam-Halsey routes, for instance, the company instituted short-line service between Borough Hall and Nostrand Avenue in the Bedford section. In addition, more cars were put into operation on routes from the subway stations to Flatbush, South Brooklyn, and Bay Ridge.⁴¹

The subway received passengers entering Manhattan on the ferries and bridges. The Fort Lee ferry, for instance, shuttled across the Hudson River between New Jersey and upper Manhattan. Before the subway was completed, the Amsterdam Avenue surface line took the ferry passengers downtown. After 1904, most passengers used the subway, especially as an electric railway was built from the ferry terminal to the One Hundred Twenty-Fifth Street IRT station on Broadway. In lower Manhattan, the subway carried riders to the boats docked at South Ferry. The Brooklyn Bridge IRT station became the most crowded subway stop upon opening, because in 1904 the bridge was the only direct connection across the East River. Following the completion of the Brooklyn subway extension as well as the Williamsburg and Manhattan Bridges and the Long Island Railroad Tunnel, passenger traffic was diverted from the Brooklyn Bridge and the East River ferryboats.⁴²

The introduction of the IRT resulted in the increase of passenger traffic. The principal consequence of the subway was to stimulate the riding habit. In New York City, the number of riders per capita increased from 274 in 1904 to 343 ten years later. With New Yorkers riding the street and rapid transit railways more frequently, patronage greatly expanded. Between 1904 and 1914, the total number of passengers in New York City advanced by more than 60 percent to 1.753 billion.⁴³ Because the growth of traffic took place without a corresponding expansion of transit facilities, travelers became more crowded over the decade. One index of traffic density is the average number of revenue passengers for each mile of single track. The U.S. Census Bureau reported that the number of passengers per track mile in Manhattan and the Bronx increased from 1.229 million in 1902 to 1.565 million one decade later. In both years, the traffic in New York was the densest in the nation. Philadelphia, Boston, and Chicago, for instance, reported densities in 1902 and 1912 that were one-half less than in New York.⁴⁴

Traffic was heaviest on the IRT. In 1915 345.5 million people rode the subway, an increase of 150 percent since 1905. The IRT totaled 3,631,296 passengers per single track mile in 1914, nearly twice the number for all New York City elevated lines.⁴⁵ Of all American railways, the Census Bureau reported for 1912, "the densest traffic is found on the subway systems in New York City."⁴⁶ In fact, the IRT bore a denser traffic than foreign subways. The number of passengers for each mile of route, a statistic not comparable with figures based on single track mileage, was about 9.508 million for the New York subway in 1914. At that time, the Paris subway numbered 7.237 million riders, the London underground 4.454 million, and the Berlin subway and elevated system 5.651 million.⁴⁷

The crowded conditions made subway travel unpleasant. Long lines formed during peak periods before the windows of harassed ticket sellers. Through the gates, passengers entered narrow platforms crowded beyond design capacity, littered with refuse, and reeking of stench. Cold in the winters, the poorly ventilated stations boiled in summertime.⁴⁸ In his address to the New York Academy of Medicine in 1906, George A. Soper said that;

No condition, excepting the heat, caused as much personal discomfort as the odors . . . The odors have been most apparent during hot, damp weather, where the greatest crowding has occurred and in those parts of the subway that are most enclosed.⁴⁹

The pressing of the crowds to board the trains reminded some observers of the Darwinian theory of natural selection. "The logical outcome of the present tendency would be a free fight at the entrance to the platform of every car," Outlook commented in January 1907, "and the opportunity of getting aboard to those who survive in the struggle."⁵⁰

Few rode comfortably. Because seats were at a premium in peak periods, passengers were often compelled to hang onto the straps for the duration of their journeys. The character of the crowd raised tensions. In close quarters, class and racial divisions were exacerbated. In addition, groups of youths went from car to car, annoying and also frightening passengers.⁵¹ Of particular concern was the sexual abuse that women endured. In 1912 Outlook noted that:

Many of (the) daily travelers are young girls. Among them are always some men not too chivalrous, and sometimes coarse-grained, vulgar or licentious. When from a skyscraper there issue simultaneously one or two thousand of these workers, to be crowded together in cars packed to suffocation, the result is not only a disregard of all conditions of comfort and health, but often also a violation of the laws of decency. The women are subjected to a crowding which at best is almost intolerable, and at its worst is deliberately insulting.⁵²

In order to survive the subway, passengers became stoical. "It must be admitted, passengers do not look their best on subways. Some read, some stare, some just placidly exist."⁵³

* * *

The overcrowding of the New York railways led a new group of reformers, the Progressives, to call for both the improvement of existing lines and also the expansion of the system. The Progressives thought of rapid transit as a panacea for slum clearance. Jacob Riis, the most prominent housing reformer of his day, called rapid transit "the key to the solution of our present perplexities."⁵⁴ In providing rapid transit between the city core and outlying sections, the subway acted to separate the home from the workplace. With rapid transit, the Progressives believed, workers no longer needed to live in the overcrowded districts near their jobs in the city center. "Though population must be concentrated," Adna F. Weber wrote in his 1902 article about "Rapid Transit and the Housing Problem" "it does not follow that population must be congested unless we assume that a man's abode cannot be separated from his workplace."⁵⁵ From the cities that bred physical disease and social pathology, laborers could move to the suburbs.

The Progressives were critical of existing conditions in the American cities, but few advocated a return to rural areas. Many of the reformers who were concerned with rapid transit had departed from the rural areas of their youth in order to take advantage of the educational and professional opportunities available in cities.

Adna F. Weber, the author of the famous study, The Growth of Cities in the Nineteenth Century, was born in Erie County, New York in 1870, attended public schools in upstate New York and also Cornell University before moving to New York City to study at Columbia University. Milo Roy Maltbie, also a native of upstate New York, received graduate degrees from the University of Chicago and Columbia. Appointed secretary for the New York City Reform Club and editor of the Progressive journal Municipal Affairs in 1897, Maltbie was also an active member of the National Municipal League. He was an economist who specialized in street railway transportation and also gas and electric utilities. William R. Willcox, who grew up on a farm in Chenango County, New York, served as the principal of several rural schools from 1882 to 1887. After moving to New York City, Willcox graduated from Columbia Law School and began to practice law. He was involved in settlement house work with reformers such as Jacob Riis and was appointed Commissioner of Parks for Manhattan and Staten Island in 1902.

In promoting the suburbs as the solution to urban problems, these Progressives wanted to retain the benefits of urban life. Their advocacy of suburbs was at once rooted in memories of their rural past and expressive of their commitment to city life. Suburbs offered not only the open air and

space of the countryside but also access to the economic centers in cities.⁵⁶ The suburbs thus acted "as a halfway house between city and country and as embodiment of the best of these diverse worlds."⁵⁷

These Progressives looked upon the development of working-class suburbs as the best solution to urban housing problems. To these critics, reform measures aimed at improving the standard of urban housing evaded the central issue of overcrowding. They believed that the ultimate remedy for housing problems was urban dispersal. Adna F. Weber argued that even though building codes and tenement house inspection laws were essential to the provision of decent urban housing, the poor could escape congestion only by abandoning the cities. Weber was especially critical of the model tenement experiment. The speculators who constructed the vast majority of tenements sacrificed even minimal building standards for the sake of higher profits, but the investors who put up the handful of model tenements limited their profits in order to provide better housing for the poor. According to Weber, the low rents of model tenements discouraged residents from relocating to the suburbs.⁵⁸

Suburbs enabled workers to live in private houses. High land costs compelled the poorer residents of most Manhattan neighborhoods to reside in tenement apartments, but land cheap enough for either the rental or purchase of small houses was available in the outlying parts of New York City. Wanting to attract as many slum dwellers as possible, the reformers needed to cut costs to a minimum. They thus envisioned one-floor houses of four to eight rooms crowded onto small building lots. Yet even these private residences were beyond the means of many workers. To encourage home ownership, the reformers favored the construction of two-family houses so that owners might apply rentals to mortgage payments. These suburban houses, though small and crowded together, would nonetheless be distant from the dirt and congestion of the city.⁵⁹

The Progressives put special emphasis on the social benefits of suburban development. Their concern for the poor was genuine, but they were equally concerned with the pathological consequences of life in the slums—crime, social deracination, and corruption. By dispersing immigrant and native workers from cities, the reformers sought to reduce social pathology. This objective entailed the assimilation of working-class groups into middle-class life.

Of particular importance was the role of home ownership. To the reformers, flat dwellers lacked the community attachments that home ownership brought. Apartment residents remained strangers even in times of distress, but householders pulled together in common cause. Home ownership also instilled personal qualities such as temperance and thrift.⁶⁰ In his 1903 article on "Small Houses for Workingmen," H.L. Cargill said that:

The tenement also meets the disposition of many to shirk responsibility. Home ownership means, not only some accumulation through thrift, but it involves a constant amount of forethought and great steadfastness of purpose.⁶¹

In addition, home ownership was understood to strengthen family life. Instead of migrating from apartment to apartment, families remained in their own homes long enough to become stable units. According to the Progressives, private houses awoke in women the domestic and homemaking instincts that lay dormant in tenements. City streets tempted the young into lives of corruption, but the wholesome surroundings of suburban homes enabled children to grow into good citizens.⁶² John Ihlder, secretary of the National Housing Association, said in 1911 that:

Flats are not houses. They have no association with home in the family sense, as children understand it in later life. The cottage is a home. The little frame house standing apart is something to which a memory can cling for good. I don't mean this sentimentally, exactly, but as taking cause and effect and the development of the family unit in one suggestion.⁶³

The Progressives associated suburban development with other reform causes. Because the largest employees of children were located in cities, the reformers hoped that the abolition of child labor would encourage families to move to suburbia. Increased wages helped workers to afford the costs of commuting and suburban housing. In addition, the reformers advocated shorter working hours in order to provide laborers with the time needed for commuting.⁶⁴

The plan for urban dispersal was dependent on the provision of adequate transportation facilities. The Progressives believed that high fares prevented workers from using transit lines.⁶⁵ "Even to the highly-paid workman," Adna F. Weber wrote in 1902, "the five-cent fare is unduly burdensome, especially if he has a large family; to the lowly-paid laborer or sweat-shop worker the prevailing rates are actually oppressive."⁶⁶ Although European railways operated separate trains for workers at discounted rates, the Progressives rejected workingmen's trains as unsuitable for a "classless" society like America. Instead, the New York reformers advised reducing the standard nickel fare for the benefit of all passengers.

Working longer hours, and settling far from the city core, laborers were expected to need rapid transportation more than well-to-do suburbanites. Both H.L. Cargill and Adna F. Weber estimated that workers were able to devote no longer than one and a half hours each day to commuting. According to Weber, average train speeds of 30 miles per hour would be required to reach working-class suburbs. In order to expand the area of settlement, moreover, these reformers favored the expansion of the rapid transit network.⁶⁷

Most reformers knew that the opening of new railways increased land values so that multiple-family structures were often built rather than private homes. But they nonetheless thought that the land would remain inexpensive enough to permit the construction of single-family dwellings. H.L. Cargill said that:

Following the development of transportation facilities and the bringing of cheap land within time limits, there will be a gradually increasing dispersal of the smaller wage-earning population into the outlying boroughs. If the tendency to erect tenements in these districts is checked in time, such a development will create a demand for small houses.⁶⁸

Within the decade, as will be shown later, the Progressives were compelled to address the effect of rapid transit lines on stimulating tenement construction in new areas. For the moment, however, the reformers were concerned with improving the transit facilities in New York.

The dispute that arose between the Progressives and the leaders of the Interborough Rapid Transit Company and the Rapid Transit Commission involved different attitudes about public service. The two groups were also distinguished by career patterns.

A number of leading Progressives were professionals with degrees from prominent universities. Milo Roy Maltbie, for instance, received doctorates from the economics departments of the University of Chicago and Columbia University. Edward M. Bassett, later president of the Citizen's Union, and William R. Willcox attended Columbia Law School. John DeWitt Warner, a founder of the Reform Club in 1887 and a frequent contributor to journals such as Municipal Affairs, graduated from a less prestigious law school in Albany. Those Progressives who were attorneys generally engaged in general practice as members of small firms. Few were corporate lawyers. Other professionals, engineers for example, usually served as consultants rather than as corporate employees. In the case of businessmen, few were associated with major corporations. President of the Municipal Art Society in 1904-5, chairman of the Citizen's Union franchise committee in 1904-5, and president of the Reform Club from 1909 to 1913, Calvin Tompkins was a leader in the struggle against the Interborough Company. Tompkins, an engineer, was the head of several New Jersey firms that produced building materials.⁶⁹

The professional and small-business orientation of the reformers played a part in their approach to public service. In opposing entrepreneurial activity in government service, the Progressives insisted on the necessity of making sharp distinctions between the public and the private interest.

The municipal engineer, for instance, should be "an engineer rather than a self-interested promoter, a public-spirited citizen rather than an over-zealous runner in the race for wealth."⁷⁰ When politicians and businessmen abused the public trust, the provision of vital social improvements was neglected.

In the case of the New York subway, Ray Stannard Baker, a noted "muck-racking" journalist, writing in the March 1905 issue of McClure's Magazine, found a clear difference between the public and private interests:

Here is the truth: if the history of the subway shows anything at all, it shows that capital all the way through has not only been greedy, not only pursued a dog-in-the-manger policy, but it has been wholly unoriginal, non-progressive. Capital wants no changes; capital 'stands pat.' Nothing could show more clearly the utter failure of private monopolies in furnishing the public - promptly - with new conveniences.⁷¹

The selfish pursuit of private interest resulted not only in inadequate public service, but also served to heighten existing social tensions. Financiers such as Belmont were indifferent to popular needs, and by displaying contempt for the public trust they invited class conflict. For the Progressives, who sought through reform to avoid overt class struggle, the distinction between public and private interest was therefore imperative.⁷²

From the perspective of the Interborough Company and the Rapid Transit Commission, the Progressive distinction between public and private interest was artificial. Unlike the reformers, the transit leaders were prominent businessmen accustomed to operating in the public realm. Their attorneys, Albert B. Boardman and Edward Shepard, were corporate lawyers. August Belmont and Seth Low were patricians from birth, but even self-made men such as Abram Hewitt became part of the elite.

Isolated from the public, the transit leaders showed little of the social concern characteristic of the Progressives. As both patricians and businessmen, the transit leaders thought of themselves as the custodians of the public welfare. Referring to August Belmont as "the community's chief public servant," the New York Times said that:

He will serve his own interests well in proportion as he serves well the interests of the people . . . his company has a business and a good will that under enlightened administration will yield millions of profit annually, as the higher the enlightenment, the greater the profits . . .⁷³

The Street Railway Journal, trade paper of the transit industry, spoke of the "partnership in improvements" between management and passengers. "however selfish the object of a company may be . . .⁷⁴ the public is the chief beneficiary or the company is heavily 'out.'"

The Progressives saw the Interborough Company as a dangerous monopoly. Ray Stannard Baker pointed out in 1905 that in addition to the subway August Belmont already controlled the Manhattan Railway Company, street car lines in Queens, and the franchise for the Steinway Tunnel projected to Brooklyn. "The aim of Belmont - and the European Rothschilds behind him," - Baker warned, "is complete monopoly."⁷⁵ According to the reformers, Belmont intended to eliminate competition in Manhattan by acquiring the Metropolitan Street Railway Company. The prospect of an IRT monopoly frightened the reformers. Once Belmont established a monopoly, the Progressives expected the IRT to neglect subway operations and to abandon expansion plans.⁷⁶

The reformers also criticized existing subway conditions. Profiting from the overcrowded transit lines, the Interborough was in fact reluctant to make improvements. The Progressives charged not only that the nickel fare was extortionary but that subway service was deficient as well. The reformers wanted more subways built, but they were not satisfied with the comprehensive plan of the Rapid Transit Commission.⁷⁷ To these critics, the comprehensive plan was designed so as to promote the creation of an IRT monopoly. In 1903 John DeWitt Warner accused the Commission of "busily laying out new (routes) to meet the views of the Belmont syndicate . . ."⁷⁸ Indeed, since most of the new lines were extensions of the original subway, only the Interborough could use them. If the Interborough refused to implement the comprehensive plan, the Progressives thought, neither the city nor another company could build the lines. The Progressives also believed that the comprehensive plan did not provide for enough lines to stimulate urban dispersal.⁷⁹

Groups of local businessmen and property owners also called for the construction of additional subways. These local associations were interested in providing their areas with transit facilities rather than implementing a comprehensive system of railways. Organizations in outlying sections frequently employed the Progressive rhetoric of urban decentralization, but their concern was generally for real estate development instead of slum clearance. In districts along the IRT, the subway overcrowding brought about demands for the building of new subways. Although the opening of the subway stimulated residential development in the Bronx, borough associations such as the North Side Board of Trade protested that the congestion was hampering further growth.⁸⁰ On February 18, 1906, the North Side News reported that:

It has become apparent that real estate operations will have to practically cease in a few years unless the Bronx is given further transit facilities. At the present time the trains and cars of the subway and elevated are jammed night and morning with people who want to get to their homes.⁸¹

The North Side Board of Trade and the Bronx League, the Taxpayer's Association and the East Side Rapid Transit Association therefore petitioned the Rapid Transit Commission to begin work on new subway projects.⁸²

The greatest demand for subway construction came from sections inaccessible to the IRT. Local boosters in Manhattan, for instance, feared that real estate development might bypass the upper east and lower west sides in favor of areas along the IRT. Joseph B. Bloomingdale, co-owner of Bloomingdale's department store, was spokesman for a committee of prominent merchants and property owners on the upper east side. "The Belmont interests," Bloomingdale said nine months before the subway opened in October 1904, "Must be convinced that the citizens of the east side are profoundly in earnest in their demand for an east side tunnel; that they have been too long put off; and that they are determined to make their demands understood by the authorities."⁸³ The West Side Rapid Transit Association, another committee of businessmen organized before the completion of the IRT, urged the construction of a subway south from the Forty-Second Street IRT station to the Battery. After the subway opened, both the West Side Rapid Transit Association and the Bloomingdale committee continued to press the Interborough and the Rapid Transit Commission. The local associations agreed with the reformers about the basic need for transit expansion, but they opposed the Progressive campaign against the Interborough for fear of delaying construction.⁸⁴

The Progressive campaign was designed to gain greater control over the Interborough Company and transit planning. Some reformers preferred municipal ownership of the subway. New York City held title to the subway in accord with the Rapid Transit Act of 1894, but the reformers understood municipal ownership as meaning government rather than private operation. Only by operating the subway itself, these critics believed, could New York establish sufficient control.

Most Progressives, however, were satisfied with reform measures aimed at restraining the Interborough. R. Fulton Cutting, chairman of the Citizen's Union, said in April 1905 that the uncertainties attending the subway project in the late 1890s justified the provisions of the original contract, but the proven financial success of the IRT warranted the letting of future contracts under more restrictive terms. The irrevocable contract for fifty years; with a renewal clause for an additional twenty-five years, enabled the Interborough Company to reap exorbitant profits and escape government supervision.⁸⁵ On

the 35 million dollar construction project alone, Ray Stannard Baker wrote in 1905, John McDonald and August Belmont made a profit in excess of six million dollars. And by the time "the cast-iron contract: expired, New Yorkers will have paid "untold millions in profits: to the Interborough in the form of the "unregulatable five cent fare." "(T)he city," Baker concluded, "has actually conveyed its right to govern."⁸⁶

The key to the Progressive plan was competition among transit interests. Because contract number one embodied a property right, the Progressives were unable to alter directly the legal terms under which the Interborough held the original subway. Instead, the reformers wanted to amend the Rapid Transit Act of 1894 in order to make bidding more competitive on new subway projects. With a number of companies from which to choose, the city could receive favorable terms and retain control. And since competition would end the Belmont stranglehold on transit expansion, the Rapid Transit Commission could also use the threat of competition to make the assignment of new contracts to Belmont conditional on the modification of the original subway terms.

In 1903 the Citizen's Union drew up a bill, known as the Elsberg Rapid Transit Bill, based on measures instituted in Boston. Its terms changed over time, but the Elsberg Bill obliged the Rapid Transit Commission to make short-term, revocable contracts for new subways, to separate construction from operational contracts, and either to lease the subways to capitalists or operate them itself.

With short-term, revocable contracts, the Rapid Transit Commission could maintain constant supervision over corporations. By compelling the Commission to let the contracts for operation and construction of the subway to the same bidder, the Rapid Transit Act of 1894 acted to restrict the bidders to major corporations such as the Interborough Company and the Metropolitan Street Railway Company.⁸⁷ The reformers looked upon the Metropolitan as one obstacle to an IRT monopoly, but they also wanted to widen the field of competitors. "This (separation of construction from operational contracts) would furnish," Ray Stannard Baker wrote, "wholesome competition and enable the public, when a new subway was built, to force really favorable terms with Belmont's monopoly."⁸⁸ In case companies refused to bid on new contracts, the provision for municipal operation was designed to give the Commission "a whip-hand over the monopoly."⁸⁹ The leading reformers preferred to use municipal operation as a device to coerce proper terms from private companies, but they also accepted municipal operation as a last resort.⁹⁰

The Rapid Transit Commission stood in the way of the reform program. Joining with the Interborough Rapid Transit Company, the Commission succeeded in defeating the Elsberg Bill until 1906. Most Commissioners believed that short-term contracts did not offer sufficient inducement to capitalists. All opposed any prospect of municipal operation.⁹¹ "I think," Albert B.

Boardman, counsel for the Commission, said in March 1904, "this is the most vicious piece of legislation I have ever seen. It is proposed to depart from every principle in the present Rapid Transit Act, and there is no reason for it."⁹²

Indeed, the Elsberg bill typified Progressive attitudes about public service that were anathemas to the Commission as well as the Interborough. The reformers saw the cooperation between the Rapid Transit Commission and the Interborough Company as a betrayal of the public. Ray Stannard Baker wrote that:

The viewpoint of the Commission itself - a civic body appointed to protect the rights of the public - is not far different from that of McDonald and Belmont, it is a business engineering view, not a broad, public, civic view. The acts of the commission from the first have been marked not by a bold, free, clear advocacy of what is best for the people, but by the halting, timid, compromising air of men imbued with the old ideals of "business interests" as compared with the "public welfare."⁹³

The resistance of the Rapid Transit Commission hampered the reformers, but it was the merger between the Interborough and the Metropolitan Street Railway, which took place in December 1905. The new enterprise, known as the Interborough-Metropolitan Securities Company, was incorporated in January 1906 with a capital of 155 million dollars. The Metropolitan operated most of the surface lines in Manhattan, and the merger gave Belmont control of nearly all the railways in that borough.

Most observers believed that the consolidation was intended to protect the Interborough investment in the subway. It was the Metropolitan, however, which in fact promoted the merger. By early 1904, the Metropolitan faced financial collapse because of overcapitalization and also the potential competition of the IRT. In an attempt to force a merger with the Interborough, Thomas F. Ryan, president of the Metropolitan, made a proposal to the Rapid Transit Commission in 1904 for the construction of an independent subway system in Manhattan. To forestall ruinous competition with the IRT, Belmont acquired the Metropolitan. This was the explanation for the merger that Belmont gave in testifying before a state legislature committee appointed in 1915 to investigate transit regulation.⁹⁴

In her 1974 dissertation "The Return on the Investment in the Interborough Rapid Transit Company," Cynthia M. Latta suggests that the threat of competition was only part of the reason for the merger. According to Latta, Belmont apparently needed consolidation to avoid losing control of the Interborough

Company. The Hudson and Manhattan Company, which was building two railway tunnels under the Hudson River from lower Manhattan to Hoboken and also Jersey City, encountered financial problems in 1905. One of the major investors in the Hudson and Manhattan Company was Walter Oakman, who was also the third voting trustee for the Interborough stock in addition to Andrew Freedman and August Belmont. Oakman wanted the Interborough to take over the Hudson and Manhattan Company, but Belmont rejected his proposal. At that point, Latta writes,

Oakman then apparently told Belmont that if he did not accede to the demands he, Oakman, would ask Ryan's help and let him into the Interborough. Freedman thereupon urged Belmont to make peace with the Ryan interests and Belmont seemed to fear that if he did not do so Freedman might decide to go with Oakman in a showdown.⁹⁵

This played into the hands of the Metropolitan. As Latta argues, Ryan wanted to merge with the Interborough rather than build another subway. A subway would not provide revenue for several years, but consolidation provided the Ryan interests with immediate income. The financial condition of the Metropolitan was so poor in 1905 that Belmont ended up with a virtually bankrupt Company.⁹⁶

The merger gave the Progressives a pyrrhic victory; they won a battle but came close to losing the war. Owing to the public reaction against the merger, the Elsberg bill was enacted in the spring of 1906. The Elsberg amendments to the Rapid Transit Act included provisions for twenty-five year leases, with twenty-year renewals, the separation of construction from operational contracts; and optional municipal operation. But the Elsberg measure, intended to forestall a monopoly and stimulate competition, was irrelevant once Belmont completed his monopoly; following the merger, the prospects for competition were nil. Ironically, then, the merger compelled the Progressives to change their strategy and propose new reforms.⁹⁷

The consolidation led to demands for the replacement of the Rapid Transit Commission. The reformers believed improved regulation was the only means of establishing control over the Interborough. Because the Rapid Transit Commission seemed neither willing nor able to control the Interborough Company, the reformers decided to oust it. The effort to establish a new public utilities commission allied groups such as the Citizen's Union, the People's Institute, the Brooklyn Central Committee, and the Citizen's Union. Lawrence Veiller, a prominent housing reformer and secretary of the City Club, was a leader in the struggle. Organizations of New York City merchants such as the Board of Trade and Transportation were also active in the legislative campaign. Powerful assistance came from Governor Charles Evans Hughes, a liberal Republican whose investigations of gas and insurance scandals were instrumental in his gubernatorial election in 1906. Hughes signed the Public Service Commissions Act into law in May 1907.⁹⁸

The Act created two five-member commissions. The jurisdiction of the second district was upstate New York, and the first district covered New York City. The law abolished the Rapid Transit Commission, transferring its powers to the Public Service Commission for the First District. Unlike the Rapid Transit Commission, whose authority was limited to the subway, the Public Service Commission supervised all of the railways in New York City, along with the gas and electric suppliers. In part this was due to the fact that the State Board of Railroad Commissioners, which regulated the surface and elevated lines, was dominated by Boss Blatt's Republican machine.

The reformers also wanted to enable the regulatory body to establish control over all of the facilities of the Interborough-Metropolitan. Of the five commissioners, three were active in the struggle against the Interborough: Milo Maltbie, Edward Bassett, and William Willcox. The fourth commissioner, John E. Eustis, was a Bronx lawyer who belonged to the City Club and once served as president of the Citizen's Union. William McCarroll was a Brooklyn manufacturer.⁹⁹

Although the Public Service Commission retained many of the engineers from the Rapid Transit Commission, their status changed. In part this was because once construction ended the need for innovation lessened and the importance of the engineers diminished. The transformation in status also resulted from Progressive attitudes about the proper role of professionals as well as the suspicions of the Public Service Commission regarding the loyalty of the old engineering staff. The reformers demanded that engineers in public service remain independent of private corporations, and they singled out William Barclay Parsons for condemnation as an entrepreneur. The Public Service Commissioners wanted to end the practice of cooperation with the IRT, but the Public Service Commission Act of 1907 required them to retain the old engineering staff in order to prevent the interruption of subway planning. There was, in fact, continuity in the engineering department for the next 17 years. The position of chief engineer for the Public Service Commission and its successor, the Transit Commission, was filled until 1924 by engineers who had worked on the original subway.¹⁰⁰ Yet none was as influential as Parsons, who had prepared most of the major engineering reports for the Rapid Transit Commission. The Public Service Commission also restricted the duties of its chief engineers to narrower technical problems instead of policy matters. And since the chief engineers did not deal intimately with the heads of private companies, they were not as independent as Parsons. Under the Public Service Commission, the chief engineers were subordinates rather than associates.¹⁰¹

Four months after entering office in July 1907, the Public Service Commissioners ordered a study of subway modifications needed to remedy the unanticipated traffic. Rather than assign its staff engineers to prepare the study, the Commission retained a prominent consulting engineer, Bion J. Arnold.

A native of Michigan, Arnold was educated at Hillsdale College in Michigan, Cornell University, and the University of Nebraska. From 1890 to 1893, Arnold served as consultant for the Intramural Railway Company of Chicago, which pioneered in building the electrified third rail on the elevated railway at the Columbia Exposition. Arnold was also a fore-runner in the development of storage batteries for the generation of electrical current, a system that the Chicago and Milwaukee Railroad and New York Central Railroad adopted under his supervision. Arnold prepared a report on the Chicago traction system in 1902 that formed the basis of the comprehensive network of railways he later implemented as chief engineer. In recognition of his achievements, Bion J. Arnold was elected president of the American Institute of Electrical Engineers in 1904 and president of the Western Society of Engineers two years later.¹⁰²

For the Public Service Commission, Arnold wrote six Reports upon the Interborough Subway, proposing major changes in subway operations. Praising the IRT "as one of the best railways in existence," Arnold explained that the modifications were needed because the volume of traffic exceeded the estimates incorporated in the subway design.¹⁰³ Because the subway design limited the extent of improvements, Arnold said the carrying capacity could be substantially increased but the subway would nonetheless remain crowded. During the next several years, the Public Service Commission instituted many of his chief recommendations.¹⁰⁴

In 1908, the Interborough began to install a new signal system designed to increase the number of express trains in service. When one train occupied the block of track in a station, the original signal system held an oncoming train in the block of track beyond the station. This system was established to ensure safe operations: a block of track was the distance required to stop a train running at full speed in addition to a safety margin of 50 percent. But the system seriously delayed trains, especially during rush hours.

The system proposed by Bion Arnold consisted of a number of automatic speed control devices that enabled trains to enter the station block slowly rather than stop completely in the next block. These speed control instruments automatically shut down any train that approached an occupied station above predetermined rates of speed. Because the permitted speed progressively decreased as the station neared, trains safely approached stations in less time than originally allowed. By November 1909, speed control devices were installed on the express tracks at the Ninety-sixth Street, Seventy-second Street, Fourteenth Street, Grand Central and Brooklyn Bridge stations. By reducing the headway between trains, the new system made possible the operation of two or three more trains per hour.¹⁰⁵

The speed control system helped to relieve the bottleneck at the junction of the Lenox Avenue and Broadway branches. After the opening of the Brooklyn subway station alleviated the overcrowding of the Brooklyn Bridge station, the junction above Ninety-sixth Street became the point of greatest congestion. North of the ninety-sixth street stop, each pair of express and local tracks was cross-connected so that trains could pass from one set of tracks to the other. Northbound trains alternated between the Lenox and Broadway divisions, and trains headed downtown changed to either the local or express tracks. Because the crossovers were in constant use, the trains were delayed at the interchange, slowing operations on the entire line.¹⁰⁶ Parsons wrote in 1908 that "this junction is found in practice to be the limiting condition of the whole railway."¹⁰⁷ Following the installation of speed controls, the capacity of the subway track at the junction was increased by one-third and the congestion eliminated.¹⁰⁸

The Public Service Commission also altered the design of the subway car. The original design, with two doors on each side at one end, proved unsatisfactory because of the heavy subway traffic. In his Report Upon the Subway Cars, Bion J. Arnold wrote that single end door cars made the lengthy delays at stations:

The present arrangement of loading and unloading passengers through the same end doors of the cars is the chief cause for inefficient operation during the rush-hour period. The crowded condition of the car entrances and station platforms . . . results in passengers leaving the cars in single file and with considerable difficulty and discomfort. The unloading under such conditions usually requires about 15 to 30 seconds, and in extreme cases 50 seconds, during the most congestive period at the principal points of transfer.¹⁰⁹

For the new design, Arnold favored the adoption of cars with two pairs of end doors on each side rather than cars with one central door and two end doors. According to Arnold, double end door cars both provided separate entrances and exits for improved circulation and also circumvented the problem of platform gaps. Passengers encountered gaps between the cars and platforms at stations such as Fourteenth Street, but the most dangerous gaps were at the two stations located on subway loops, City Hall and South Ferry. Because the distance from the curved platform to the center of the cars was about two feet at each station, the operation of center-side door cars was especially difficult.

After a double end door car was put on trial service in February 1909, however, the Interborough Company and the Public Service Commission rejected the Arnold design as incapable of improving passenger circulation. Instead,

the Interborough adopted the center-side door car and also proceeded with the development of mechanical gap fillers. In addition to converting the original single-end door cars, the Interborough ordered the first lot of 250 new cars in June 1909 from the American Car and Foundry Company, the Pressed Steel Car Company, and the Standard Steel Car Company. All express trains were equipped with the new cars by 1911, and one year later the center side door cars began to operate on the locals.¹¹⁰

The Public Service Commission wanted to add more cars to the local and express trains. At the time, the length of station platforms limited express trains to eight cars and locals to five. By operating ten-car expresses and seven-car locals, Arnold estimated that each train could carry at least 250 more passengers. Even if the number of trains running on one express track remained constant at 30 per hour, the maximum carrying capacity of 10 car trains would be 37,500 passengers per hour, an increase of one quarter over the eight car expresses.¹¹¹

In 1909, the Public Service Commission decided to lengthen platforms to accommodate ten-car expresses and six-car locals. South from Ninety-sixth Street, express platforms were extended to provide access to the center doors of the end cars. The local platforms on the main line were lengthened to reach all doors of six car trains. The Commission directed the Interborough Company to adapt Lenox division stations as far north as Third Avenue for 10 car trains, but only the uptown platforms of the Broadway and other Lenox stations were to be enlarged. The six car locals were inaugurated in October 1910 and the 10 car expresses in January 1911.¹¹² After one year of operation, the Commission credited the longer trains for the "perceptibly improved conditions during the rush hours."¹¹³

The technical modifications increased the capacity of the subway, but the rapid traffic growth sustained the overcrowding. The Public Service Commission reported in 1912 that the modifications made since 1907 enhanced train operations. During that period, the average headway decreased from 2 minutes 4 seconds on express tracks and 2 minutes 8 seconds on local tracks to 1 minute 48 seconds for both services. Consequently, the Interborough operated an average of 33 trains per hour in 1912 compared to 29 trains five years earlier. And since the trains were longer and ran more frequently than before, they provided about 40% more seats per hour. These were major improvements. In view of the added traffic, however, the Public Service Commission concluded that the principal effect of the modifications was to prevent the congestion from worsening.¹¹⁴ "Yet this vastly increased traffic is handled with no greater congestion and inconvenience to passengers than obtained in 1907."¹¹⁵ The Commissioners neglected to mention that by 1907 the overcrowding was already far too great.

The Commission recognized that IRT improvements were merely palliative. Some points of delay were incorporated in the subway itself, On the Lenox

Avenue branch between Ninety-Sixth and One Hundred Tenth streets, for instance, curves in the tracks required trains to proceed slowly. Since northbound trains alternated between the Lenox and Broadway divisions, the defective track restricted all operations above the junction. "Little did the builders of the subway think," the Electric Railway Journal commented in 1911, "that a long stretch of track on one division beyond the four-track section would ever limit the capacity of the entire section."¹¹⁶ It was difficult to correct problems such as the Lenox track because of the high costs and also the interruption of subway service. But even if further modifications were made, the Commission knew that the great volume of traffic would continue to overwhelm the IRT.

1. New York Tribune, October 28, 1904.
2. New York Mail & Express, October 28, 1904; New York Commercial, October 31, 1904; New York Sun, November 1, 1904.
3. Real Estate Record and Builders Guide, November 5, 1904, 949.
4. "The Rapid Transit Problem," Street Railway Journal, March 18, 1905, 501; William Barclay Parsons to Alexander E. Orr, February 19, 1903, 207-208. In Board of Rapid Transit Railroad Commissioners, Report 1903 (New York: n.p., 1904).
5. "The Rapid Transit Problem" Street Railway Journal, p. 501.
6. New York Tribune, October 28, 1904; October 7, 1905; Daniel L. Turner, "Is there a Vicious Circle of Transit Development and City Congestion?", National Municipal Review, June 1926, 322; Board of Rapid Transit Railroad Commissioners, Report 1904 (New York: n.p., 1905), 261; Abraham Lincoln Merritt, "Merritt Journal," May 2, 1908, February 16, 1914, Electric Railroaders Association, New York.
7. Bion J. Arnold, Reports Upon the Interborough Subway. Report no. 4, The Capacity of the Subway, (New York: Public Service Commission, First District, 1907-1908), 7.
8. U.S. Department of Commerce and Labor, Bureau of the Census, Street and Electric Railways, 1902 (Washington, D.C.: Government Printing Office, 1905), p. 38.
9. New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929 (Albany; J.B. Lyon Company, 1930), 85-86; New York Times, October 29, 1904.
10. New York State Public Service Commission - First District Investigation of Interborough-Metropolitan Company and Brooklyn Rapid Transit Company, v. 1 (New York Law Reporting Company, 1907), 25: 3-254.
11. U.S. Department of Commerce and Labor, Bureau of the Census, Street and Electric Railways, 1907 (Washington, D.C.: Government Printing Office, 1910), 29.
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13. H.H. Vreeland, "Cars and Car Service in Metropolitan New York," Street Railway Journal, October 13, 1900, 959; Street Railway Journal, April 4, 1908, 581; New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 85.
14. U.S. Department of Commerce and Labor, Bureau of the Census, Street and Electric Railways, 1902, 36. The 1901 statistic is for the year ending September 30; Street Railway Journal, June 16, 1900, 516; Chicago Public Library, Municipal Reference Library, A Study Rapid Transit in Seven Cities, Municipal Reference Bulletin No. 3 (Chicago: Municipal Reference Library, 1914), 16; New York State Public Service Commission First District, Report 1910, v. III (Albany: J.B. Lyon Company, 1911), 26-27.
15. New York Times, July 1, 1901, November 1, 1901, March 19, 25, 1902; William Fullerton Reeves, The First Elevated Railroads in Manhattan and the Bronx of the City of New York, The John Divine Jones Fund Series of Histories and Memoirs, IX (New York: The New York Historical Society, 1936), 43; "The Electrical Equipment of the Manhattan Elevated Railway," Street Railway Journal, January 5, 1901, 10; 10; "The Opening of the Manhattan Elevated Railway," Street Railway Journal, January 18, 1902, 82; New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 85-86; Glen E. Holt, "The Changing Perception of Urban Pathology," 331. In Kenneth T. Jackson and Stanley K. Schultz, eds., Cities in American History (New York: Alfred A. Knopf, 1972).
16. New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 85-86; Street Railway Journal, April 4, 1908, p. 581.
17. "Crowded Cars," Street Railway Journal, May 17, 1902, 605.
18. William Barclay Parsons to Alexander E. Orr, February 19, 1903. In Board of Rapid Transit Railroad Commissioners, Report 1903, 208.
19. Ibid.; Alexander E. Orr to William Barclay Parsons, May 29, 1902. In Board of Rapid Transit Railroad Commissioners, Report 1902, (New York: n.p., 1903), 65-68; Board of Rapid Transit Railroad Commissioners, Report 1906 (New York: n.p., 1907), 18; New York Evening World, October 28, 1904; Real Estate Record and Builders Guide, September 19, 1904, p. 526, July 23, 1904, p. 177.
20. Board of Rapid Transit Railroad Commissioners, Report 1902, 310.

21. William Barclay Parsons to Alexander E. Orr, February 19, 1903. In Board of Rapid Transit Commissioners, Report 1903, 208.
22. William Parsons Barclay to Alexander E. Orr, February 19, 1903. In Board of Rapid Transit Railroad Commissioners, Report 1903, 209-214; William Barclay Parsons to Alexander E. Orr, March 12, 1903. In Board of Rapid Transit Railroad Commissioners, Report 1903, 215; New York Sun, October 23, 1904; James Blaine Walker, Fifty Years of Rapid Transit, 1864-1917 (New York: n.p., 1918), 149.
23. "Rapid Transit Subways in Metropolitan Cities," Municipal Affairs, September 1900, 478-479; Robert H. Whitten, "Comparison of Operation of the New York and Paris Subway Systems," Electric Railway Journal December 11, 1909, pp. 1178-1184; New York World, October 2, 1904.
24. William Barclay Parsons, The New York Rapid-Transit Subway (London: Institution of Civil Engineers, 1908), 86-89.
25. William Barclay Parsons to Alexander E. Orr, February 19, 1903. In Board of Rapid Transit Railroad Commissioners, Report 1903, 210-212; Chicago Public Library, Municipal Reference Library, A Study of Rapid Transit in Seven Cities, 7-8; Reeves, Reeves, The First Elevated Railroads, 43; New York State Board of Railroad Commissioners, Eighteenth Annual Report, v. II (Albany: J.B. Lyon Company, 1901) 839.
26. New York World, October 2, 1904.
27. London County Council, The Rapid Transit Subways of New York (London: Southwood, Smith, 1904), 32; Arnold, Reports Upon the Interborough. Report No. 7 The Traffic of the Subway, 15-17.
28. William Barclay Parsons to Alexander E. Orr, February 19, 1903. In Board of Rapid Transit. Railroad Commissioners, Report 1903, 249; Arnold, Reports Upon the Interbrough Subway. Report No. 3, Report Upon the Subway Car, 3-8.
29. Parsons, The New York Rapid-Transit Subway, 49.
30. The Merchant's Association of New York, Passenger Transportation Service in New York (New York: n.p., 1903), 13-19, 97-105; New York State Board of Railroad Commissioners, Twenty-Third Annual Report, vol. II (Albany: Brandow Printing Company, 1906), 1181; New York State Public Service Commission - First District, Report 1907, vol. II (New York: Public Service Commission - First District, 1908), 29; New York Commercial, August 2, 1907.

31. New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 95; New York State Public Service Commission - First District, Report 1907, vol. II, 29; Arnold, Reports Upon the Interborough Subway Report No. 6. The Traffic of the Subway, 17; New York State Public Service Commission - First District, Investigation of Interborough-Metropolitan Company and Brooklyn Rapid Transit Company, v. 1, 130-131; New York Times, August 29, 1907; New York Evening Mail, August 3, 1907.
32. "Subway Conditions About Normal," Street Railway Journal, November 2, 1904, 893.
33. City Club of New York, New York City Transit (New York: M.B. Brown, 1907), 24-27; Board of Rapid Transit Railroad Commissioners, Report 1903 256; New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 88; New York Evening Post, August 7, 1907; Charles M. Higgins, City Transit Evils: Their Causes and Cure (Brooklyn: n.p., 1905), 7.
34. Higgins, City Transit Evils: Their Causes and Cure, 7.
35. New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929 90, 97. The Mileage Statistics include an unspecified amount of track owned by the Westchester Electric Railroad Company and located in Westchester County. Ibid.
36. Street Railway Journal, February 10, 1906, 252.
37. Ibid.,; New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 85; Board of Rapid Transit Railroad Commissioners, Report 1906, 254.
38. From 1908 to 1914, the total length of all railway track in Brooklyn increased 4 percent to 608 miles. Statistics before 1908 classify track in Queens with that in Brooklyn, and statistics before 1919 make an arbitrary division between Brooklyn elevated and surface track "owing to the existence of a considerable mileage having mixed characteristics." New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 90-91, 95-97; Manhattan surface track increased from 281 miles in 1900 to 295 miles in 1914. The miles of track operated by the Manhattan Railway Company; later the elevated division of the Interborough Rapid Transit Company, in Manhattan and the Bronx numbered 109 in 1900 and 117 in 1914. Ibid., 90-91, 96-97.

39. Abraham Lincoln Merrit, "Merrit Journal," January 9, 1908; "Effect of New Tunnel on Brooklyn Traffic," Street Railway Journal, January 25, 1908, 153; Street Railway Journal, January 18, 1908; New York State Public Service Commission - First District, Report 1912, v. 1 (Albany: J.B. Lyon Company, 1913), 189.
40. "Effect of New Tunnel on Brooklyn Traffic," Street Railway Journal, 153.
41. Electric Railway Journal, January 2, 1909, 46; New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 85.
42. Alan Paul Kahn, The Tracks of New York. No. 1 Metropolitan Street Railway, 1907 (New York: Electric Railroaders Association, 1973), Figure 1; Board of Rapid Transit Railroad Commissioners, Report 1903, 226; Board of Rapid Transit Railroad Commissioners Report 1905 (New York: n.p., 1906), 63. New York City Department of Docks and Ferries, Thirty-Ninth Annual Report (New York: n.p., 1911), 21; New York State Public Service Commission - First District, Report 1912, v.1, 189; Street Railway Journal, January 18, 1908, 88-89.
43. New York State Department of Public Service, Metropolitan Division, Transit Commission, Ninth Annual Report: 1929, 86-87; New York State Public Service Commission - First District, Report 1910 v. III (Albany: J.B. Lyon Company, 1911), 25-31.
44. U.S. Department of Commerce, Bureau of the Census, Central Electric and Power Stations and Street and Electric Railways, 1912 (Washington, D.C.: Government Printing Office, 1915), 214-215.
45. New York State Department of Public Service, Metropolitan Division, Transit, Commission, Ninth Annual Report: 1929 86; Chicago Public Library, Municipal Reference Library, A Study of Rapid Transit in Seven Cities, 16.
46. U.S. Department of Commerce, Bureau of the Census, Central Light and Power Stations and Street and Electric Railways, 1912, 214-215.
47. Chicago Public Library, Municipal Reference Library, A Study of Rapid Transit in Seven Cities, 16. The only foreign line for which the number of riders per single track miles was reported was London, which averaged 1.070 million in 1914. In 1914 the lengths of the subway routes were: New York, 29.1 miles; London, 40.2 miles; Berlin, 5.5 miles; and Paris, 48.5 miles. Ibid.; Traffic on the Paris and Berlin subways was dense because neither extended far beyond the city core. For the Paris subway, see Robert H. Whitten, "Comparison of Operation of New York and Paris Subway Systems," Electric Railway Journal, December 11, 1909, 1178-1184.

48. New York State Public Service Commission - First District, Report 1910 v.1 (Albany: J.B. Lyon Company, 1911), 441-443.
49. George A. Soper, "The Condition of Air of the Rapid Transit Subway," Street Railway Journal, March 31, 1906, 496.
50. "The Discomforts of New York," Outlook, January 5, 1907, 15.
51. Ibid., "The Strong-Arm Brigades," Electric Railway Journal, August 26, 1911, 340; Holt, "The Changing Perception of Urban Pathology," 327-333.
52. "New York's Subway Problem: A Review," Outlook, June 22, 1912, 386.
53. James Joseph McGinley, S.J., Labor Relations in the New York Rapid Transit System (New York: King's Crown Press, 1949), 18.
54. Quoted in Roy Lubove, The Progressives and the Slums: Tenement House Reform in New York City, 1890-1917 (Pittsburgh: University of Pittsburgh Press, 1962), 111.
55. Adna F. Weber, "Rapid Transit and the Housing Problem," Municipal Affairs, Fall 1902, 411.
56. Municipal Affairs, Fall 1902, 506; National Cyclopaedia of American Biography, v.A (New York: James T. White and Company, 1930), 445; National Cyclopaedia of American Biography, v. 14 (Ann Arbor: University Microfilms, 1967), 382; Joel A. Tarr, "From City to Suburb: The 'Moral' Influence of Transportation Technology," 202-212. In Alexander B. Callow, Jr., ed., American Urban History, 2nd. ed., (New York: Oxford University Press, 1973).
57. Tarr, "From City to Suburb: The 'Moral' Influence of Transportation Technology," 203.
58. Ibid.; Adna F. Weber, The Growth of Cities in the Nineteenth Century (Ithica: Cornell University Press, 1967), 469-475; Weber, "Rapid Transit and the Housing Problem," Municipal Affairs, 415; Lubove, The Progressives and The Slums: Tenement House Reform in New York City, 1890-1917, 6-11.
59. Weber, "Rapid Transit and the Housing Problem" Municipal Affairs, 412-424; New York Times, September 17, October 10, 1910; Robert Coit Chapin, The Standard of Living Among Workingmen's Families in New York City (New York: Charities Publication Committee, 1909), 75-84; H.L. Cargill, "Small Houses for Workingmen," 331-335, 346-353. In Robert W. DeForest and Lawrence Veiller, eds., The Tenement House Problem, v.1 (New York: MacMillan, 1903).

60. New York Times, September 17, 1911; Lubove, The Progressives and the Slums: Tenement House Reform in New York City, 1890-1917, 131-132; Lawrence Veiller, "Housing Conditions and Tenement Laws in Leading American Cities," 131-136. In DeForest and Veiller, eds., The Tenement House Problem, v.1.
61. Cargill, "Small Houses for Workingmen," 352.
62. Ibid., 351-353.
63. New York Times, September 10, 1911.
64. Weber, "Rapid Transit and the Housing Problem," Municipal Affairs, 412-417; H.L. Cargill, "Small Houses for Workingmen," 331-332.
65. H.L. Cargill, "Small Houses for Workingmen," 331-332; Chapin, The Standard of Living Among Workingmen's Families in New York City, 111-114.
66. Weber, "Rapid Transit and the Housing Problem," Municipal Affairs, 414.
67. Ibid., 412-414; Cargill "Small Houses for Workingmen," 331-332; New York City Commission on Congestion of Population, Report (New York: Lecouver Press, 1911), 25.
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69. National Cyclopaedia of American Biography, v. 44. (New York: James T. White and Company, 1962) 548; Who's Who in New York, 7th ed, (New York: Who's Who Publications, 1917), 1063.
70. Robert A. Bruere, "George Staples Rice," Outlook, May 25, 1907, 191.
71. Ray Stennard Baker, "The Subway 'Deal'", McClure's Magazine, March 1905, 469; See also R. Fulton Cutting, "Public Ownership and the Social Conscience," Municipal Affairs, March 1900, 3-7; West Side Citizen's Transit Reform Committee of One Hundred, Report of Executive Committee (New York: n.p., 1903), 5-7; and Higgins City Transit Evils: Their Causes and Cure, 6-15.
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73. New York Times, December 24, 1905.
74. Street Railway Journal, January 4, 1902, p. 31.
75. Baker, "The Subway 'Deal,'" McClure's Magazine, 468.

76. Ibid.
77. Ibid, 467-469; Outlook, June 24, 1911, 369.
78. John DeWitt Warner, "Municipal Ownership Needed to Correlate Local Franchises," Municipal Affairs, Winter 1902-1903, 516.
79. Baker, "The Subway 'Deal,'" McClure's Magazine, 467-469; Outlook, June 24, 1911, 369; Higgins, City Transit Evils: Their Causes and Cure, 6; Brooklyn Eagle, February 22, 1906; New York Evening Post, August 7, 1907; New York Press, February 20, 1906.
80. New York Telegram, December 29, 1906; New York World, July 24, 1905.
81. North Side News, February 18, 1906.
82. Ibid.
83. New York Times, January 26, 1904.
84. New York World, October 2, 1904, July 24, 1905; New York Times, December 10, 1908.
85. R. Fulton Cutting, "Shall New York Own Its Subway?" Outlook, April 15, 1905, 931-933; "New York's Subway Problem: A Review," Outlook, 384-388; Outlook, December 29, 1906; William J. Gaynor, "New York's Subway Policy," Municipal Affairs, June 1901, 434; Baker, "The Subway 'Deal,'" McClure's Magazine, 463-469; Warner, "Municipal Ownership Needed to Correlate Local Franchises," Municipal Affairs 515-524.
86. Baker, "The Subway 'Deal,'" McClure's Magazine, 494.
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90. Cutting, "Shall New York Own Its Subway?", Outlook, 931-933.
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93. Baker, "The Subway 'Deal,'" McClure's Magazine, 462-463.
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96. Ibid., 67-76.
97. New York Evening World, December 23, 1905; Outlook, April 21, December 29, 1906.
98. Brooklyn Eagle, March 10, 1907; New York Herald, December 27, 1907; Wall Street Journal, February 26, 1907; Robert F. Wesser, Charles Evans Hughes: Politics and Reform in New York, 1905-1910 (Ithaca: Cornell University Press, 1967), 21-33, 154, 160-169.
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100. George S. Rice, who succeeded William Barclay Parsons as chief engineer of the Rapid Transit Commission, continued in that capacity for the Public Service Commission until late 1907. Henry B. Seaman, the division engineer in charge of the first IRT section until 1902, was chief engineer from 1907 to 1909. Alfred Craven, second division engineer and also deputy chief engineer during the IRT construction, served as chief engineer between 1910 and 1916. Daniel L. Turner, an assistant engineer who worked on subway drainage and surveys for the Brooklyn extension, was chief engineer of the Public Service Commission and then the Transit Commission from 1916 to 1921. Formerly an assistant and division engineer for the Rapid Transit Commission, Robert Ridgeway was employed by the Transit Commission as chief engineer between 1921 and 1924. National Cyclopaedia of American Biography, v. 12, (New York: James T. White and Company, 1904), 82-83; Who's Who in New York, 9th ed., (New York: Who's Who Publications, 1929), 15-17, 393; National Cyclopaedia of American Biography, v. E (New York: James T. White and Company 1938), 77-78, 91-92; Walker, Fifty Years of Rapid Transit, 1864-1917, 183, 189-191.

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102. National Cyclopaedia of American Biography, v. 14, 62-64; New York State Public Service Commission - First District, Report 1908, v.1, 9.
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104. Arnold, Reports Upon the Interborough Subway. Report No. 4, The Capacity of the Subway, 3-7.
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106. "The Neck of the Bottle," Electric Railway Journal, February 11, 1911, 248; New York State Public Service Commission - First District, Report 1910, v.1, 85; Street Railway Journal, February 29, 1908, 343; Parsons, The New York Rapid Transit Subway, 31-32.
107. Parsons, The New York Rapid-Transit Subway, 32.
108. "The Neck of the Bottle," Electric Railway Journal, 248; Electric Railway Journal, February 19, 1910, 315.
109. Arnold, Reports Upon the Interborough Subway. Report No. 3, Reports Upon the Subway Car, 7.
110. Ibid.; "History of Center-Door Cars for the New York Subway," Electric Railway Journal, February 10, 1912, 246-247; Electric Railway Journal, August 19, 1911, 320; "Extensible Platform in New York Subway," Electric Railway Journal, February 21, 1914, 421-422; Merritt, "Merritt Journal," March 1, 1909; October 27, 1910; November 11, 1912.
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112. Ibid., 11-12; New York State Public Service Commission - First District, Report 1909, v.1, 91-92; Merritt, "Merritt Journal," October 24, 27, 1910; January 23, 1911.

113. New York State Public Service Commission - First District, Report 1911, v.1, (Albany: The Argus Company, 1912), 107.
114. New York State Public Service Commission - First District Report 1912 v.1, (Albany: J.B. Lyon Company, 1913), 51-52, 190-191.
115. Ibid., 53.
116. "The Neck of the Bottle," Electric Railway Journal, 248.

The introduction of the subway affected land-use patterns in New York City. The IRT was one of several transit improvements that contributed to the northward movement of the commercial districts that were already encroaching on residences in mid-town Manhattan. In Mid-town, the subway played the largest role in the emergence of Times Square as a city-wide entertainment center. On the upper West Side, the subway allowed for both the development of Broadway as a business district and also for the construction of elite apartment buildings on West End Avenue and Riverside Drive. The greatest impact of the IRT was on the undeveloped territories in the Bronx and northern Manhattan. The Progressives wanted private houses to be erected in these new areas, but the actions of land and building speculators brought about the construction of tenements for the poor.

The subway, though increasing the likelihood of development, could not cause it. The subway itself was incapable of making an area successful. The introduction of transit facilities provided access to either new or established areas, but residential and commercial development depended on conditions such as the intensity and character of the demand for the land, the supply of municipal services, and the state of the building market.¹

Nothing came from the projections that the IRT would establish Fourth Avenue from Fourteenth to Twenty-Fifth Street as a major retail center. At the turn of the century, this district was an amalgam of old apartments and houses, churches and charities, hotels and a few modern business buildings.² The New York Times later recalled lower Fourth Avenue as a "street of hotels, antique shops, and undertaking establishments."³ The downtown area was in transition, with the northward movement of commercial districts already advancing on residential area, but Fourth Avenue was stagnant. Although the opening of the subway provided stations at Fourteenth, Eighteenth, Twenty-third, and Twenty-eighth Streets, retail businesses bypassed the avenue. "It is true that hitherto the avenue has been somewhat of a disappointment," the Real Estate Record and Builders Guide said in April 1905. "It has not justified as yet the predictions of these people who believed that the subway would make it much more desirable for retail purposes than it formerly was, and that it would become a second 6th Avenue."⁴

Instead, a boom in the construction of buildings with office and loft space began in 1909. At Fourth Avenue and Eighteenth Street, for instance, office buildings replaced the Belvedere House, the Florence House, and the Clarendon Hotel in 1909. The subway played a part in this transformation, but the entire section grew because wholesalers required locations at an accessible distance from the retail districts uptown.

The IRT contributed to the northward expansion of commercial districts. This movement resulted largely from the encroachment of the garment industries on the old commercial center below Twenty-third Street. In the decade following the completion of the subway in 1904, the Hudson and Manhattan tubes were extended to the Thirty-third street and the Pennsylvania Station was opened. The construction of these lines served to reinforce the northward movement.⁵

Few major stores were built on the subway route. Because stores such as Tiffany's and B. Altman's catered to the well-to-do carriage trade, they were located on Fifth Avenue at sites easily accessible to the upper east side rather than along the subway. As Fifth Avenue became a major shopping center, businesses that served a more varied clientele also clustered there, especially on the cheaper land to the south. Middle-class department stores needed to be near transit facilities, but they did not locate on the IRT route. At the turn of the century, these department stores were centered on Fourteenth Street at Sixth Avenue. By moving further uptown on Sixth Avenue, also the route of an elevated line, many department stores remained within the general vicinity of the old retail concentration. In 1901, Macy's began to build at Herald Square the first major department store beyond Twenty-third Street. This store was situated both at the intersection of Broad and Sixth Avenue and also near the planned Pennsylvania station. In 1901, Andrew P. Saks leased the block front on the west side of Broadway between Thirty-third and Thirty-fourth Streets for his first New York store.⁶ "The subway has, indeed, altered the line of traffic," the Real Estate Record and Builders Guide noted in 1906, "but so far this alteration has not affected the retail trade."⁷

Of all mid-town areas, the subway played the greatest role in the growth of Times Square. In the 1890's, Long Acre Square, as Times Square was known before April 1904, was a center of horse stables and carriage stops. To the west of Seventh Avenue, Hell's Kitchen was notorious for its slums and factories. The renovation of the Long Acre Square area began in the early 1890's with the arrival of the Metropolitan Opera House, the Empire Theatre, and the Olympia Theatre, but the announcement of the subway project gave impetus to the development. In part, the importance of the IRT station was derived from its status as an express stop and as the southernmost station on the west side. The principle reason for the significance of the station was that Long Acre Square seemed destined to become a nexus of midtown. Situated at the confluence of Forty-second Street, Seventh Avenue, and Broadway, the diagonal avenue forming the spine of Manhattan, Long Acre Square was one of the great centers of New York. In providing access to the square, during the time of the expansion of mid-town, the IRT stimulated the growth of the area. In 1900, one electric and two cable railways already operated through Long Acre Square, along with a crosstown line, but most observers believed the subway would put the square within reach of nearly all New Yorkers.⁸ The coming of the IRT persuaded the Real Estate Record and Builders Guide in 1900 that:

. . . there can be no doubt that the whole neighborhood of Long Acre Square, north and south, east and west, will be the scene during the next ten years of a very considerable activity. Indeed it is not too much to say . . . that it is rapidly becoming the centre of the Borough of Manhattan - the centre, that is, not of its business activities but of that aspect of Metropolitan life which is every year becoming more important - its public social and pleasure - seeking activities . . . There more than any other spot, do people gather from the east and west, the north and south; and this tendency to so gather will be increased by all the forces which make for the growth of New York City. When the tunnel is completed the neighborhood will be more accessible from more points than any other neighborhood in the city.⁹

Brownstones, tenements, and stables gave way before the onslaught of building activity. By 1902 the Astor Hotel and the New York Times Building were already under construction. Times Square was becoming the Piccadilly Circus of New York.¹⁰

The subway also enhanced the development of Times Square as a theatre district. Like many kinds of businesses, theatres settled in clusters that functioned to attract customers. Because playhouses required central locations that offered access to transit facilities, theatre districts had earlier formed at Union, Madison, and finally Herald Square. Some theatres were already present at Times Square by 1900, but the subway brought about an invasion of the area.¹¹ Of the 65 theatres and amusement places that Phillips' Business Directory counted in Manhattan and the Bronx in 1900, five were located in the 12-block section bounded by Sixth and Eighth Avenues and by Fortieth and Forty-eighth Streets. Fifteen years later, this Times Square area was the address of 35 in 100 amusement places, a five-fold increase. These lists included establishments such as music halls and skating rinks, in addition to the majority of legitimate theatres concentrated near Times Square by 1915.¹² "The theatre district now extends from West Thirty-fourth Street northward along Broadway," the New York Times reported in 1907. "Playhouses further south, on or near the main thoroughfare, are practically doomed."¹³ In 1906 the Real Estate Record and Builders Guide found a "concentration of theatrical businesses in that one vicinity (Times Square) the likes of which has never been seen in New York before."¹⁴ The first theatres were constructed on Broadway, but rising real estate costs forced the builders of establishments such as the Lyceum and the New Amsterdam onto side streets. By 1920, movie houses were taking the place of the legitimate theatres that had already begun to leave Broadway for crosstown streets.¹⁵

Unlike previous centers of theatres, hotels, and restaurants Times Square grew without important retail businesses. This created an imbalance in the use of the land. "(Theatres and hotel) should be associated with

all sorts of general business," the Real Estate Record and Builders Guide said in January 1909," so that the real estate will be earning an income during the daytime as well as at night."¹⁶ With the theatres busy only after dark, and without the retail shops to create activity in the day, Times Square would later be infiltrated by businesses such as brothels, which profited at all hours.¹⁷

* * *

The subway played a major role in the development of the upper west side between Seventy-second and Ninety-sixth Streets. After 1904, Broadway replaced Columbus Avenue as the main business thoroughfare in the district. The most intensive development occurred near the IRT stations, where the largest apartment buildings and stores were erected. In addition, streets such as Seventy-second became shopping areas. The coming of the IRT also stimulated residential growth west of Broadway. Ten to fourteen story apartments covering as much as half a block-front went up on Riverside Drive and West End Avenue.

At the turn of the century, Broadway from Seventy-second to Ninety-sixth Street was unevenly developed. Because the major transit line on the west side, the Ninth Avenue elevated, ran along Columbus, that avenue had become the principal business thoroughfare of the district. Two blocks away from Columbus, Broadway was a more inconvenient location for both businessmen and residents. Thus while commercial and residential buildings were concentrated on Central Park West, Columbus and Amsterdam Avenues, the development of Broadway, West End, and Riverside was sporadic.¹⁸

The only local business center of any consequence on Broadway in 1898 was Sherman Square, the intersection of Broadway, Amsterdam, and Seventy-second Street. On the west side of Sherman Square, the Rutgers Riverside Presbyterian Church and the 8-floor Hotel St. Andrew shared the blockfront between Seventy-third and Seventy-second Streets. One block south stood the Colonial Club and the Christ Protestant Episcopal Church. At Seventy-first Street, the Sherman Square Hotel occupied the southwest corner and the Roman Catholic Church of the Blessed Sacrament the southeast corner. East of Broadway from Seventy-first to Seventy-second, a 12-story apartment building was located on the southern corner, while the northern corner was taken by brownstones that fronted onto the side street. Opposite these row houses, the northeast corner of Seventy-second and Amsterdam was vacant.¹⁹

North of Sherman Square, Broadway was sparsely developed. Here and there large apartment houses were scattered, for instance the Lyonhurst at Seventy-sixth, the Saxony at Eighty-second, the Versailles at Ninety-first, and the Wollaston and Wilmington between Ninety-sixth and Ninety-seventh. But most of the land was held in large plots by owners awaiting an increase

in land values. Because these owners were unwilling to sell or make permanent improvements before the demand for their property grew, most of the land was either vacant or the site of small, temporary structures. On the eastern side of Broadway in 1898, the blockfronts between Seventy-sixth and Seventy-seventh, Seventy-ninth and Eightieth, and Eighty-fifth and eighty-sixth were unimproved. The entire block bounded by Eighty-sixth and Eighty-seventh and by Broadway and Amsterdam was vacant. No buildings were contained on the blockfronts west of the Boulevard from Ninety-seventh to Ninety-sixth, Ninety-fifth to Ninety-fourth, Ninteith to Eighty-ninth, and Eighty-seventh to Eighty-fifth. Of the 84 street corners from Seventy-sixth to Ninety-sixth, nearly 30 were vacant in 1898.

On developed land, the most common buildings were the one- or two-story "taxpayers" that housed small businesses. Taxpayers were temporary structures intended to earn an income sufficient to repay the cost of construction and to cover the taxes on the land and the buildings. Because the erection of these inexpensive structures entailed less risk than the erection of more elaborate buildings, taxpayers were constructed in districts undergoing an uncertain change in land use patterns. Taxpayers were built in response to temporary conditions, but they often survived long after the transformation in land use made possible the construction of structures that made more intensive use of the land. In 1898, taxpayers occupied the eastern sides of the blocks north of Eighty-second and Seventy-eighth.

The other structures ranged from frame shacks to 5-story brick tenements with businesses on the ground floors. There were even coal yards at Eighty-eighth and Ninety-fifth Streets. The vacant land and the irregular buildings gave Broadway a coarse appearance at the turn of the century.²⁰ "Probably no leading thoroughfare in the city had so many low buildings and taxpayers as Broadway . . .," the Real Estate Record and Builders Guide later recalled. "The result was that Broadway presented anything but an attractive view. The vacant property was in most instances surrounded with broad fences, usually covered with unsightly posters and the small buildings were anything but architectural monuments."²¹

The introduction of the subway brought about an increase in land values. In providing access to the territory west of Amsterdam Avenue, the IRT made possible a more intensive use of the land. From 1905 to 1913, the assessed valuation of the taxable land east of Amsterdam between Seventy-second and Ninety-sixth Streets rose only 11 percent, but the land values west of Amsterdam advanced by 34 percent. The greatest increases occurred on the river front. Land values between Riverside and West End Avenues increased 38 percent, compared to 34 percent for the blocks on both sides of Broadway. Although the riverfront values registered the largest proportional increase, the absolute value of the Broadway land became the highest on the upperwest side.²²

The IRT initiated a building boom that transformed Broadway into a retail center. Construction chiefly took the form of elevator apartments over 10 stories high and smaller business structures. Because the upper west side lacked the demand for office space that distinguished the central business district, the Broadway apartment houses were at first the only tall structures erected there, with their ground floors intensively used for retail businesses. Following the opening of the subway, the most important mode of mass transit in the district, Broadway supplanted Columbus Avenue as the principal shopping district of the upper west side. Retailers were also attracted because Broadway provided the best connections both within the upper West side and also with outside areas, especially mid-town Manhattan. This avenue ran not only diagonally through the entire borough but also near the center of the West Side above the sixties. Largely because Central Park presented a barrier to east-west communication, the section of Broadway north of Seventy-second Street was basically a local business district. Automobile dealers began to cluster north of Columbus Circle in the sixties, but businesses that wanted to appeal to a city-wide clientele generally did not venture above Sherman Square.²³

The most intensive development took place near the subway stations. Since the volume of pedestrian traffic was greatest on street corners with subway stops, large apartment houses, banks, theatres, and drugstores located there. As both an express stop and the junction of the Lenox and Broadway divisions, the Ninety-sixth Street station was one of the most important on the IRT. Between 1905 and 1915, more people patronized the Ninety-sixth Street stop than any of the other four stations in this section of the Upper West Side (see Table 1.). Commercial development was hampered because the Nineties were less accessible to mid-town than the southern parts of the Upper West Side, but the heavy subway traffic enabled the

Table 1. Number of Tickets Sold at Upper West Side Stations, 1905-1915

	1905	1906	1909	1911	1913	1915
96th Street	2,657,887	3,119,254	4,493,427	4,777,460	5,464,885	5,669,595
91st Street	979,789	1,107,070	1,436,685	1,497,891	1,609,518	1,790,513
89th Street	1,792,043	1,998,850	2,916,879	2,935,126	3,079,906	3,321,533
79th Street	1,596,388	1,874,677	2,622,810	2,578,925	2,753,851	2,987,047
72nd Street	2,447,122	2,918,757	4,018,694	4,171,246	4,484,207	4,657,515
Total	9,473,229	11,018,608	15,488,694	15,960,648	17,392,367	18,426,20

Sources: Annual Reports of the Board of Rapid Transit Railroad Commissioners and the Public Service Commission - First District

Ninety-sixth Street area to become an entertainment center by 1921. A 6-story building that housed the Riverside Theatre and a 7-floor structure that contained a theatre and roof garden occupied most of the block front east of Broadway between Ninety-sixth and Ninety-seventh. On the southwest corner of Ninety-sixth and Broadway, a bowling alley was the tenant of a 2-story building. One block further south stood the Symphony Theatre.²⁴

The Ninety-first Street IRT station served the fewest passengers of any Upper West Side subway stop. Neighborhood residents preferred to patronize the express station located only five blocks to the north. And since Ninety-first was not a major crosstown street like Ninety-sixth, Eighty-sixth, Seventy-ninth, and Seventy-second, the Ninety-first Street station received less pedestrian traffic than the others. The result was that the Ninety-first Street stop exerted little influence on its surroundings. The 6-story Versailles apartment house at Ninety-first and the 7-floor St. James Court at Ninety-second both predated the announcement of the IRT project. On the block front between Ninety-first and Ninetieth east of Broadway, the only improvements made by 1921 were a group of small, single-floor buildings, most of them constructed away from the streets. The 12-story Tintern and a 13-floor apartment stood on the northern corners of Ninety-first, but this type of building was common to all parts of Broadway.²⁵

Large apartment buildings went up near the Eighty-sixth and Seventy-ninth Street IRT stations. The Belnord Apartments, largest in the world upon completion in 1908, was built on the entire block bounded by Eighty-sixth and Eighty-seventh Streets and by Broadway and Amsterdam. Opposite the Belnord was a small retail building. Two apartment hotels, the Euclid Hall and the Bretton Hall, were located on the block fronts from Eight-sixth to Eighty-fifth. At the northeast corner of Eighty-sixth Street, adjacent to the IRT station, the New York Produce Exchange Bank rented office space in the Bretton Hall in 1921. The neighborhood around the Seventy-ninth Street stop was dominated since 1908 by the Apthorpe apartment building, which covered the block between Seventy-ninth and Seventy-eighth and between Broadway and West End Avenue. The Apthorpe, like the larger Belnord, was a 12-floor building designed in Renaissance style and constructed around a large central court. The Apthorpe was owned by the Astor estate, which retained much of the Upper West Side property acquired decades earlier by John Jacob Astor. The family also erected the Astor Apartments between Seventy-fourth and Seventy-fifth Streets and the Astor Court Apartments between Eighty-ninth and Ninetieth. Across Seventy-ninth Street from the Apthorpe, the First Baptist Church was finished 13 years before the IRT opened. A department store was housed in the 2-story building at the northeast corner of the intersection, while a 12-floor apartment was located at the southeast corner.²⁶

The IRT allowed for the growth of Sherman Square as the major business center on the Upper West Side. The passenger traffic through the Ninety-sixth Street station was slightly heavier than through Seventy-second Street,

but Sherman Square offered merchants a location both at the junction of the two avenues and also accessible to mid-town. The opening of the Seventy-second Street express station stimulated the further development of Sherman Square. In December 1905 the New York Times reported that:

The present strong position held by Sherman Square property may, of course, be traced directly to the operation of the subway. Before the opening of the underground road the availability of this neighborhood for hotels and apartment houses had been thoroughly demonstrated, but it needed the subway crowds to give it prominence as a business centre and to bring about that increase in values which comes with large ground floor rentals. Broadway and Seventy-second Street has to a very large degree supplanted Columbus Avenue and Seventy-second Street as the great distributing points for traffic to and from a considerable area on the West Side, . . . It is probably a conservative estimate that Sherman Square values have increased at least 20 or 25 per cent since the opening of the subway.²⁷

In discussing the outlook for Sherman Square, the Real Estate Record and Builders Guide in 1905 also put special emphasis on the subway.

The square at 72nd St. and Broadway is becoming one of the most important in the city, and is likely to become still more important. It has the advantage of a subway express station, of the location in the vicinity of many huge apartment hotels, and consequently of a great and growing density of population.²⁸

Following the completion of the IRT, Sherman Square was reconstructed. Built on the block front from Seventy-fifth to Seventy-fourth and developed by W.E.D. Stokes, the Ansonia was finished in 1904. This 17-story apartment hotel was a prestigious New York address. Two blocks further south, the Colonial Club was converted into an office building, known as the Lincoln Trust Building, between 1905 and 1907. The Christ Church occupied the entire corner at Seventy-first Street before 1925, but the Broadway end of the church was demolished at that time and replaced by a 8-story office building. The Sherman Square Hotel at the southeast corner of Seventy-first and Broadway was sold in 1904 to new owners who made extensive alterations on the old building. In 1921, the Church of the Blessed Sacrament completed work on new buildings located east of Broadway between Seventieth and Seventy-first which was intended to replace the old church at the southeast corner of Broadway and Seventy-first. This church was demolished in order to make way for an 18-story apartment hotel, the St. Gerard Apartments. Opposite the site of the old church, the Dorilton Apartment House was completed in

1900. Because many people passed the southeast corner of Seventy-second Street and Broadway on their way to the subway station in the center of the square, the Import Cigar Company leased the site of a former school house several years after the IRT opened. The northeast corner was vacant before 1904, but two 12-story apartments that covered the entire block front were put under construction in 1905. The ground floors of the Sherman Square apartment buildings were rented to businesses such as restaurants and clothing shops that profited from the pedestrian traffic. The reconstruction transformed Sherman Square into a prominent business center.²⁹

The land near IRT stations was put to the most intensive use, but the other sections of Broadway were also developed. Only one street corner between Seventy-sixth and Ninety-sixth was vacant in 1921. No coal yards remained, and a number of old buildings were demolished. Yet many of the earlier structures survived, such as the taxpayers lining the eastern block front north of Eighty-seventh Street. The subway made possible higher levels of land use, but previous uses often did not become obsolete since parts of Broadway were already improved with apartments and retail buildings. There were frequently little profit in replacing structures able to function adequately under changed conditions. This was especially true of the areas away from the IRT stations that showed smaller increases in land values. And because much of the improved property was held in small parcels, a number of different decisions entered into the process of development resulting in a mix of old and new buildings.

The most common type of new building was the 12-story apartment erected on half a block front. The Wellsmore was built at Seventy-seventh Street, the Admaston at Eighty-ninth, the Cornwall at Ninetieth, and the Roxborough at Ninety-second. The other apartment houses covered smaller lot areas and rose fewer stories. Retail stores rented the ground floors of these buildings. In general, the construction of the largest and most luxurious apartment houses was confined to the valuable sites adjacent to IRT stations. In addition to apartments, 2- and 3-floor business buildings also went up on Broadway.³⁰

Following the completion of the IRT, some of the major crosstown streets on the Upper West Side emerged as shopping districts. The subway stimulated their growth, but these streets were already important by 1904. In 1807 the New York State Legislature authorized the appointment of a commission to lay out a street plan for New York City north of Houston Street. All the side streets platted by the Commission of 1807 were 60 feet wide, except for 15 that were 100 feet in width. These were the streets numbered: 14, 23, 34, 42, 57, 72, 79, 86, 96, 106, 116, 125, 135, 145, and 155. As New York grew northward, these side streets became the principal thoroughfares for crosstown traffic. Indeed, the Interborough Company and the Rapid Transit Commission built most stations on the main crosstown streets in order to

attract the largest volume of traffic to the subway. The IRT served to enhance the development of these streets. On the Upper West Side, the Seventy-second Street block between Broadway and Columbus Avenue became the crosstown street of greatest consequence after 1904. The 4-story and basement brownstones that lined the street were constructed as elite private residences during the 1880s, but the block lost favor shortly before the turn of the century and some buildings were altered to boarding houses. The location of the block between two centers of commerce and transit offered an ideal site for businesses. To the west, Sherman Square was not only a growing business area but also the junction of two surface railways. Owing to the elevated station at Columbus and Seventy-second, that neighborhood was also an important retail district. After the opening of the IRT greatly increased the number of pedestrians on Seventy-second Street, retailers began to move onto the block. The brownstones were converted into shops at first, but the row houses were later demolished to make way for large apartment buildings that also provided more space for businesses.³¹

Above the Upper West Side, the IRT stimulated the development of businesses on streets such as One-hundred-sixteenth. By 1915 a retail district extended several blocks to the east and west of the IRT stop at One-hundred-sixteenth and Lenox Avenue, an area that was also served by an elevated and several surface railways. Two theatres built in 1913, the 116th Street Theatre and the Regent, were located between Seventh and Lenox Avenues. One block east, at 60 West One-hundred-sixteenth, was the Regun Theatre. At least six movie houses were situated from Eighth to Third Avenue, including the Empress, the Mecca, the Princess, and the Crown. William Waldorf Astor owned the Graham Court, a luxurious 8-story apartment building constructed in 1901 on the east side of Seventh Avenue from One-hundred-sixteenth to One-hundred-seventeenth. A 4-story office building was at the southeast corner of Eighth Avenue, and another office building, the Bernheimer Building, was at the northeast corner of Lenox. A 3-floor building on the block between Fifth and Lenox housed the Columbia Typewriter Company. Most of the six banks located west of Morningside Avenue were concentrated in the area between Fifth to Eighth Avenues. Retail shops included clothing and drugstores, and liquor and furniture dealers. In addition to private enterprises, political clubs, churches and temples, schools, and a post office were among the tenants of One-hundred-sixteenth Street.³²

The completion of the IRT also stimulated the construction of large apartment houses on Riverside Drive and West End Avenue. During the 1880s, private residences were built on parts of both roads, but the boom soon ended. In part this owed to the fact that the East Side remained the fashionable residential district for the elite. Charles Schwab, president of U.S. Steel, erected his mansion on Riverside Drive from Seventy-third to Seventy-fourth Streets shortly after the turn of the century, but most prominent New Yorkers built their houses on the East Side. The two avenues also languished because of the inadequacy of transit facilities.

Since the Columbus Avenue elevated railway was distant and the Broadway surface railway slow, house seekers avoided the area as inconvenient. More houses were built on West End than Riverside during the late nineteenth century because the cheaper land attracted middle-class residents and the avenue was one block nearer the elevated line.³³

The IRT initiated the construction of large apartments on both avenues. By providing access to the riverfront land, the subway made possible the building of luxurious apartment houses on Riverside Drive. The New York Times reported in 1904 that:

The Subway changed the conditions that retarded the residential development of Riverside, however, and with adequate transportation facilities at hand, the natural attractions of the Drive have again caused it to assume a prominent position in the city's building operations . . . This new construction, by reason of the value of the land, has been of the highest type, and it is evident that the Drive's popularity with apartment dwellers is to be fully as great and certainly more permanent than was its popularity with the builders of fine residences. The unobstructed outlook up and down the river gives an added attraction to its corners, and in this respect the Drive is unique among Manhattan's north and south avenues.³⁴

Modern apartments lined Riverside Drive by 1916. Apartment buildings over five stories high were located between Seventy-ninth and Ninety-sixth Streets, including 12-floor houses. These apartments typically consisted of suites of five to ten rooms that included quarters for servants. Although Riverside Drive became an elite residential area, the New York Central Railroad tracks that ran like a scar through Riverside Park diminished the appeal of the waterfront. The City of New York prepared plans in 1911 for covering the tracks, building a depressed highway for trucks, and landscaping the park, but improvements were not made until the 1930s. Because the highway designed for passenger cars was built above ground at that time, the defacement of the riverfront continued.³⁵

Apartments also went up on West End Avenue after 1904. Since builders were first attracted to the less developed and more valuable riverfront land, West End Avenue was neglected until about 1907. According to the estimates of the Real Estate Record and Builders Guide in 1912, the construction of apartments resulted in the destruction of about one-half of the private dwellings existing in 1907. By 1916, 32 apartments over six stories high were located on West End from Seventy-second to Ninety-sixth Street, including 17, 12-story and eight, seven-floor structures. For the most part, the West End flats were less luxurious than the apartments built on the costlier riverside property.³⁶

* * *

The Progressives and other groups expected private homes to be built in the new areas of Manhattan and the Bronx that the subway opened up for development. To these New Yorkers, the IRT was important as a means of removing slum dwellers from overcrowded urban districts to the suburbs. "The greatest benefit of the underground railway . . . will come . . . from the fact that it increases the habitable area of the city tenfold, and leaves no possible excuse for slums and overcrowded flat dwellings except the more than suspected preference of the people who now inhabit them," the New York Public Opinion commented on November 3, 1904. "The subway has at least made it possible for a New Yorker, even if he is not a millionaire, to live in a private dwelling within reach of his business."³⁷ The Real Estate Record and Builders Guide opposed most Progressive measures aimed at regulating tenement houses as economically unsound and as infringements on property rights, but the journal strongly advocated suburban development. In September 1904 the Record and Guide stated:

What is much more serious is the fact that the millions of people who elect to live in Manhattan are, for the most part obliged to inhabit small, cramped and uncomfortable tenements and flats, which exercise a bad influence both upon the physique of their tenants and upon the character of their domestic lives. New Yorkers lack good air, good sunlight, and enough space for comfort, and the great want of the subway is that it will begin the process of restoring to the inhabitants of the city sufficient allowance of habitable room, air and sunlight . . . It will begin the process of restoring cheap residential land to Manhattanites.³⁸

Because of real estate speculation, however, tenements were constructed in the new areas rather than private homes. Speculators profited from the increase in land values that accompanied changed in land use patterns. Much of the land in northern Manhattan and the Bronx was fully improved for uses such as farming before 1904, but the coming of the IRT made possible more intensive use of the property accessible to the subway.³⁹ Edwin H. Spengler wrote that:

The conversion of farm land into land which is suitable for residential or business use, has the effect of multiplying its value many times. The subway appears to serve the purpose of increasing the possibility of such conversion or of causing it to take place sooner than it would ordinarily require. To this extent it is instrumental in facilitating a rise in land values.⁴⁰

This transformation to higher levels of usage was the source of speculative earnings. After acquiring tracts in anticipation of increased values, the

New York speculators retained the property until the subway was nearing completion. At that time, they began to either sell the land in small parcels to other speculators for the construction of residences or else develop some of it themselves.⁴¹

For the most part, land speculation was the province of professional realtors connected with leading politicians, traction magnates, and capitalists. These entrepreneurs were able to reduce the risks inherent in speculation. By receiving inside information about the subway route, the speculators bought the land with the potential for the greatest increase in value before the prices rose. In order to fund large operations, professionals needed entry into the circles of financiers. Professional and amateur speculators alike lacked reliable standards with which to project increases in values, determine appropriate uses of the land, and set retail prices, but past experience permitted professionals to make better judgment than amateurs. Because these speculators belonged to networks of realtors, they also obtained access to buyers.⁴²

Henry Morgenthau was a leading speculator in the Bronx and Manhattan. He emigrated from Germany at the age of nine in 1865. After attending public schools and the City College of New York, Morgenthau graduated from the Columbia University Law School and began to practice real estate law in 1877. Morgenthau continued to practice law for the next two decades, but he became increasingly involved in real estate promotions. By selling 44 Washington Heights lots in 1891 to buyers who mistakenly anticipated the prompt construction of a subway through the area, Morgenthau received an advance of 170 percent on an equity of \$300,000. After acquiring 41 lots located between Avenue A and First Avenue and between Fifth and Seventh Streets for \$850,000 in 1898, Morgenthau built tenements on the properties. In 1899 Morgenthau discontinued his law practice and founded the Central Realty Bond and Trust Company. He served as president of the Company until its merger with the Lawyers' Title and Insurance Company six years later. In 1903 Morgenthau helped organize the United States Realty Company, the directors of which included financiers such as Cornelius Vanderbilt and Charles Schwab and politicians such as Hugh J. Grant and Charles H. Tweed. The following decade, Morgenthau was selected as chairman of the finance committee of the Democratic Party and also as ambassador to Turkey. His son, Henry Morgenthau, Jr., served as Secretary of the Treasury for Franklin D. Roosevelt. Owing to his associations with politicians and capitalists during the early 1900s, Morgenthau was able to receive the information and financial backing needed to buy large amounts of property in advance of transit improvements. Before the IRT route was known to the public, a syndicate headed by Morgenthau acquired tracts in the Washington Heights and Fort Dyckman sections of northern Manhattan and also in the south Bronx. On Washington Heights, for instance, Morgenthau bought some 140 lots around the IRT express station projected at One-hundred-eighty-first Street and Broadway.⁴³

Charles T. Barney was probably the largest speculator in land along the IRT. He was born in Cleveland in 1851, the son of A.H. Barney, president of the U.S. Express Company and himself a real estate speculator. Charles T. Barney entered the circle of New York City entrepreneurs through his marriage in 1875 to a sister of William C. Whitney, one of the most powerful traction magnates in New York and also an influential figure in the Democratic Party. Barney was associated with the Knickerbocker Trust for most of his career, serving as vice-president from 1884 to 1898 and as president until shortly before his death in 1907. He was also a special partner in the firm of Rogers and Gould, members of the New York Stock Exchange. By 1900, Barney was an experienced real estate operator. Ten years earlier, Barney, Whitney, W.E.D. Stokes, Francis M. Jencks and other financiers formed a syndicate, known as the New York Loan and Improvement Company, to develop land in the upper west side and Washington Heights. During the next decade, Barney also took an active part in real estate transactions in downtown areas, but he returned to northern Manhattan after 1900. At that time, Barney was appointed as one of the original directors of both the Rapid Transit Subway Construction Company and the Interborough Rapid Transit Company. When August Belmont refused to detour the subway route from Barney's home at Park Avenue and Thirty-eighth Street, Barney sold his interest in both companies. This was perhaps the only time that he ever objected to the effect of rapid transit improvements on his properties.⁴⁴

Barney's early involvement in the IRT project was the key to his success as a speculator. It provided him with advance knowledge of the subway route and the assurance the subway would be completed on time. This assurance was important because experienced speculators were often reluctant to risk the acquisition of land alongside projection transit lines for fear that the lines might be either seriously delayed in opening or never finished. "Mr. Barney was one of the men most intimately concerned with the initiation of the subway project in New York," the Times noted in 1907, "and with his real estate operator's instinct he went again largely into realty investment on the upper west side along the route that was then known to only a few of the inner circle of subway financiers."⁴⁵ Barney acquired upper west side parcels such as the four vacant Broadway corners at the Eighty-sixth Street IRT station, but most of his transactions were made in northern Manhattan and the Bronx.

In order to raise capital for the venture, Charles T. Barney formed a syndicate that included: George Rumsey Sheldon, a New York banker who was a specialist in street railway finance, the treasurer of the New York County Republican Committee from 1899 to 1903, and National Republican Committeeman in 1903-1904; Francis M. Jencks, who was president of the Safe Deposit Company of New York and formerly a partner in the New York Loan and Improvement Company; and William F. Havemeyer, Jr., named after his father, a three-term mayor of New York City and ally of William C. Whitney and Abram Hewitt in the struggle of reform Democrats against Boss Tweed during the early 1870s.

According to the New York Times, the Barney syndicate invested about \$6.9 million in vacant property north of One-hundred-twenty-fifth Street. The syndicate began operations in Washington Heights and Fort George, but by 1901 the buying was extended to the Inwood area and the Bronx. At that time, the syndicate acquired 109 lots in the vicinity of the Broadway division stations at Two-hundred-twenty-fifth Street and Two-hundred-thirty-fifth Street in the Bronx. No inventory of syndicate property seems to exist, but Charles T. Barney held title to about 360 parcels of varying size in his own name.⁴⁶

The speculators subdivided their parcels into lots intended mostly for sale to small-scale builders. Since the southernmost tracts provided the best access to downtown Manhattan, they were the first to be sold. In February 1904 the Barney syndicate began to dispose of 150 lots located between Broadway and Riverside Drive from One-hundred-thirty-fifth to One-hundred-thirty-seventh. The syndicate auctioned off most of its holdings during the next 18 months and all of them by 1907. Most land was sold to builders, but some speculators retained parcels to develop themselves. The American Real Estate Company acquired in 1899 an 86-acre tract in the Bronx that extended from Westchester Avenue and Southern Boulevard toward the Harlem River. Although much of the property was sold to developers, the American Real Estate Company built stores, apartments, and duplexes near the Simpson Street IRT stop.⁴⁷

Tenements were built in the new areas. The construction of private homes was uneconomical because of the high land costs. All types of apartments made more intensive use of the land, but building speculation brought about the erection of low-grade multiple-unit dwellings. The building speculators were generally small operators who lacked the capital to make more substantial improvements. Tenements not only provided a sufficient income relative to land costs but also were cheap enough for speculators to erect. These speculators abandoned construction standards in favor of high profits. Since most tenements were built for sale rather than for investment purposes, the speculators were not induced to maintain standards, especially as the structures were often sold before completion. In order to increase their profits and also to put their capital back into operation before the boom ended, the builders hurried construction and cut costs.⁴⁸ The New York Times reported in 1908 that:

. . . the speculative spurt was so rampant and so many (tenement) houses were being sold from the plans - many, indeed, before the cellars had been dug - that, there was an ever present temptation to 'skin' the buildings. Material prices were at top notch, and with all responsibility for a building's future value and attractiveness off his hands, the builder's interest in many cases naturally ended with putting up a structure as cheaply and rapidly as possible.⁴⁹

Because tenements diminished the appeal of neighborhoods, builders who commanded greater resources than most speculators were reluctant to erect more elaborate structures in the area. The result was that tenements predominated in much of northern Manhattan and the Bronx. The Times concluded that, "there were launched in various sections a vast number of ill-advised and ill-considered operations. Structures were put up without regard to renting prospects and without regard to the requirements of a neighborhood."⁵⁰

In upper Manhattan, the boom in tenement house construction began in 1904. This building activity continued at a high level until about 1907. At the height of the boom in 1905, the New York City Tenement House Department recorded 560 building plans for the district west of Lenox Avenue between One-hundred-tenth and One-hundred-fifty-fifth, a fourteen-fold increase since 1902. The 1,396 plans that were filed for this district from 1902 to 1908 amounted to nearly one-third of the total for the entire borough. (See Table 2). During this period, preparations were made for 472 tenements located north of One-hundred-fifty-fifth Street, ten percent of the number for all of Manhattan. Of the 3,174 tenements houses that were counted north of One-hundred-thirtieth Street in 1909, two-fifths were built since 1902. (See Table 3). Northern Manhattan contained more than thirty percent of the 3,932 new tenements constructed throughout the borough since 1902 but only 7.4 percent of the total number of tenements in Manhattan. At that time, the buildings were concentrated on the lower East Side.⁵¹

In the Bronx, the tenement house was the predominant form of construction in the boom that began after 1904. The number of structures for which plans were filed nearly tripled from 882 in 1902 to 2,278 three years later. (See Table 4). In 1910 the estimated cost of the proposed buildings was seven times greater than in 1902. Of the 16,192 construction plans submitted to the Bronx Bureau of Buildings during the eight-year period, 28 percent were for tenements. In that time, the estimated cost of the tenements amounted to about 60% of the total \$229.2 million. More than 20 percent of the 7,258 tenements that the Tenements House Department enumerated in the borough in 1909 were built after 1902.⁵²

The building of tenements was centered along the IRT in both areas. Most tenements in Manhattan were constructed within one block of either the Lenox or Broadway divisions, and nearly all were located no further than two blocks from the subway. The tenements were concentrated north of One-hundred-thirty-ninth Street to the Harlem River on the Lenox line and from One-hundred-thirtieth to One-hundred-sixtieth on the Broadway branch. Because the higher riverfront values attracted more expensive structures, tenements were not prevalent in the block between Broadway and Riverside Drive.⁵³ The New York World noted in September 1905 that in the Bronx "there is now a distinctive Subway zone of flat houses extending almost solidly from Third Avenue north-easterly to Simpson Street . . . The zone extends on both sides of Westchester Avenue and the Boston road, and on the west side of Southern Boulevard."⁵⁴ The Bronx Bureau of Buildings reported in 1911 that:

Table 2. Location of Tenements in Manhattan for which plans were filed, 1902-1908.

	1902		1903		1904		1905		1906		1907		1908		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Below 14, east	99	38.2	207	45.1	136	16.3	82	5.6	99	10.6	76	23.2	18	7.2	719	15.9
Below 14, west	35	13.5	44	9.5	46	5.5	9	3.6	11	1.1	24	7.1	17	6.8	186	4.1
14-59 Sts, east	25	9.6	27	5.8	36	4.3	41	2.8	55	5.9	35	10.4	9	3.6	228	5.0
14-59 Sts, west	8	3.0	5	1.0	11	1.3	8	0.5	17	1.8	14	4.1	5	2.0	68	1.5
59-110, east	17	6.5	45	9.8	151	18.3	300	20.7	152	16.4	19	5.6	13	5.2	697	15.4
59-110, west	21	8.1	24	5.2	63	7.5	85	5.8	62	6.6	16	4.7	12	4.0	283	6.2
110-155, east	12	4.6	14	3.0	93	11.1	187	12.9	132	14.2	13	3.8	6	2.4	457	10.1
110-155, west	38	14.6	75	16.3	260	31.1	560	38.7	271	29.2	108	32.2	84	33.7	1396	30.3
North of 155	4	1.5	18	3.9	38	4.5	172	11.9	127	13.7	28	8.3	85	34.1	472	10.4
Manhattan	259	100.0	459	100	834	100	1444	100	926	100	335	100	249	100	4506	100

Source: New York Tenement House Department, Fourth Report, 1907-1908

Table 3. Distribution of Tenements in Manhattan by date of construction, February 1909.

	1*	%	2**	%	3***	%
	No.		No.		No.	
Scuth of 14 St., east of Broadway	8,896	20.9	8,242	21.3	654	16.6
South of 14 St., west of Broadway	3,181	7.4	3,017	7.8	164	4.1
14th-40th Sts., east of 6th Ave.	2,674	6.2	2,536	6.5	138	3.5
14th-40th Sts., west of 6th Ave.	3,466	8.1	3,440	8.9	26	0.6
40th-86th Sts., east of 6th Ave.	5,939	13.9	5,627	14.5	312	7.9
40th-86th Sts., west of 6th Ave.	4,311	10.0	4,234	10.9	77	1.9
86th-130th Sts., east of Lenox Ave.	7,157	16.8	6,318	16.3	839	21.2
86th-130th Sts., west of Lenox Ave.	3,757	8.8	3,291	8.5	466	11.8
North of 130th St.	3,174	7.4	1,918	4.9	1,256	31.9
Total, Manhattan	42,555	100.00	38,623	100.0	3,932	100.00

Source:

* (1) All Tenements

** (2) Tenements built before 1902

*** (3) Tenements built since 1902

Table 4. Number and Estimated cost of Tenements and all Structures for which plans were filed,
The Bronx, 1902-1910

	All Structures	Tenements	Percent	All Structures	Tenements	Percent
1902	882	72	8.1	\$6,503,900	\$1,789,5000	27.5
1903	795	88	11.0	6,792,800	2,001,500	29.4
1904	1,684	489	29.0	23,068,100	14,960,700	64.8
1905	2,278	762	33.4	38,313,400	20,142,600	73.4
1906	2,246	464	20.6	27,622,700	16,140,100	58.4
1907	1,967	373	18.9	20,784,600	8,664,300	41.6
1908	1,912	437	22.8	21,415,100	10,642,700	49.6
1909	2,402	870	36.2	40,748,600	29,252,500	71.8
1910	2,026	971	47.9	44,034,400	34,920,000	79.3
Total	16,192	4,526	27.9	229,283,500	146,513,900	63.9

Source: New York City, Borough of the Bronx, President, Annual Report, 1910 and 1911

The line of the Subway and the adjacent streets and avenues . . . aggregate about 20 linear miles. This represents but $2 \frac{3}{5}$ percent of the mileage of all the streets and avenues already laid out in the Bronx, excluding all undeveloped acreage . . . (Yet) 23 percent., or nearly one-quarter of all new buildings erected in the Bronx during the past seven years have been erected within that small proportion of developed territory.⁵⁵

The opening of the IRT brought about population increases in northern Manhattan and the Bronx. In New York City, the population was concentrated near rapid transit facilities. Nine of ten New Yorkers lived within one-half mile of rapid transit lines in 1925. Between 1905 and 1920, the number of Manhattanites residing north of One-hundred-fifty-fifth Street grew more than 70 percent, or from 123,000 to 216,000. In 1905, nearly 240,000 people lived along the Lenox Avenue division in northern Manhattan, an area bounded by the Harlem and East Rivers, Eighth Avenue, and One-hundred-ninth Street. The population of this district, parts of which were already developed before the subway opened, advanced 40 percent by 1920. The combined population for these two districts increased by one-half during the fifteen year period, one-tenth greater than the total for all of Manhattan. From 1900 to 1920 the number of people who resided in the Bronx grew by 265 percent to 732,016, compared to 65 percent for the entire city.⁵⁶

The IRT played a limited role in relieving the overcrowded slum districts. For the most part, unskilled workers remained behind in the residential areas that provided easy access to their jobs in the central cities. These lowly paid laborers were unable to afford the nickel subway fare. Since wives and children often worked in addition to adult males, the cost of commuting would have been higher for poor families than for families of better means in which adult males were more likely to be the sole wage earners. Because the only free transfer point on the IRT was at Third Avenue and One-hundred-thirty-ninth Street in the Bronx, many laborers would have had to pay an extra fare in order to reach their places of work. For laborers who spent 10 or 14 hours a day at work, the traveling time of one to one and a half hours between job and home was prohibitive. Since many unskilled workers lacked secure employment and were compelled to move from job to job, they were unable to count on regular journeys to work. These workers required residences in central areas that offered a network of information about job opportunities and a nexus of transportation facilities.

However, the subway did allow families of improving means to escape the slums more easily than before. By opening vast new areas for development, the subway served to lower the threshold required for relocation. The housing in the new districts was affordable, and the time and cost of commuting were manageable. To these New Yorkers, the tenements of northern Manhattan and the Bronx were a considerable step up from the tenements of the Lower East Side.⁵⁷

After the construction of tenements ended their dream of suburbs for workingmen, the Progressives began to promulgate zoning codes partly in an attempt to curtail the impact of transit lines. Their efforts culminated with the enactment of the 1916 resolution, the first comprehensive zoning law in the United States. This code established building zones intended to segregate land uses. By regulating the height, area, and use of buildings, the planners hoped to prevent the encroachment of commercial on residential areas and of densely populated residential on suburban districts. To the New Yorkers who took part in the zoning campaign, the development that followed the opening of the IRT was a prime instance of the need for regulation. Among the members of the Commissions that prepared the zoning code were former Public Service Commissioners Milo R. Maltbie, William Willcox, and Edward M. Bassett.⁵⁸ According to Bassett, who served as chairman of the New York City Heights of Buildings Commission from 1913 to 1915 and later became a nationally recognized authority on zoning, the code was essential because "new subways (that) produced only increase congestion of living and business conditions . . . would be of doubtful benefit to the city."⁵⁹ In his testimony before the New York City Commission on Building Districts and Restrictions in 1916, Nelson P. Lewis, Chief Engineer of the New York City Board of Estimate and Apportionment, said that:

I remember the sensational development of the Washington Heights districts on the completion of the present subway . . . (U)nless there is some restriction on kind of development which can occur, I think we will have a serious problem for the city to deal with . . .⁶⁰

During the decade that followed the opening of the IRT and that witnessed the construction of tenements throughout the new areas, the reformers went from promoting new subways to seeking means of limiting their impact. No longer was the subway a panacea.

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56. U.S. Department of Commerce, Bureau of the Census, Twelfth Census of the United States: 1900. Bulletin 11. (Washington, O.C., Government Printing Office, 1900), 15; U.S. Department of Commerce, Bureau of the Census, Fourteenth Census of the United States: 1920. vol. III Population, (Washington, O.C.: Government Printing Office, 1922), 710; Cities Census Committee, Inc. Population of the City of New York, 1890-1930. (New York: Cities Census Committee, Inc., 1932), 83-84; Regional Plan of New York and Its Environs, Regional Survey of New York and Its Environs, vol. II. Population, Land Values and Government, 76-79.
57. Robert Coit Chapin, The Standard of Living among Workingmen's Families in New York City (New York: Charities Publication Committee, 1909), 75-84.
58. Lawrence Veiller, "The Safe Load of Population on Land," Proceedings of the Second National Conference on City Planning and the Problems of Congestion (Cambridge: University Press, 1910), 72-79; Lawrence Veiller, "Protecting Residential Districts," Proceedings of the Sixtieth National Conference on City Planning (Boston: University Press, 1914), 98-110; Edward M. Law, "The Preparation of the Building District Map of the City of New York," Municipal Engineers Journal, November 16, 1916, 107.1-107.15; Edward M. Bassett, Zoning (New York: Russell Sage Foundation, 1940), 7-12, 45-63; New York City Heights of Buildings Commission, Report (New York: np., 1913), 1; New York Commission on Building Districts and Restrictions, Final Report (New York: Board of Estimate and Apportionment, 1916), 2-5; Seymour Toll, Zoned American (New York: Grossman Publishers, 1969), 3, 144-147, 172-181.
59. Bassett, Zoning, 7.
60. New York City Commission on Building Districts and Restrictions, Final Report, 147.

HISTORIC AMERICAN ENGINEERING RECORD
INTERBOROUGH RAPID TRANSIT SUBWAY (ORIGINAL LINE)

NY-122

"DESIGN AND CONSTRUCTION OF THE IRT: CIVIL ENGINEERING"

Location:	New York City, New York UTM: (Indeterminable) Quad: Brooklyn, Central Park
Date of Construction:	1900-1904
Present Owner:	City of New York
Significance:	The IRT was New York City's first subway.
Historian:	Charles Scott, 1978.

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The October 24, 1885, ENGINEERING NEWS AND CONTRACT JOURNAL announced:

Mr. W. B. Parsons, Jr., has resigned his position as Roadmaster of the Susquehanna, Div., Erie Railway, and has opened an office as Civil Eng. at 35 Broadway, N.Y. Room 73.¹

William Parsons, future Chief Engineer of the Rapid Transit Commission and one of the men most responsible for New York's first subway, the IRT, had returned to the city in which he had acquired his engineering education.

William Barclay Parsons graduated from Columbia College in 1879. The following fall he entered the Columbia School of Mines, from which he received a degree in civil engineering in 1882. Shortly thereafter, he joined the Erie Railroad, where he was assigned to the division engineer's office at Port Jervis, New York. From Port Jervis, Parsons moved to Rochester, where he supervised the reconstruction of the Erie's "Rochester Division." His experiences on the Erie provided him with the material for his two textbooks on railway maintenance of way, TURNOUTS (1883), and TRACK (1884). At the urging of his brother-in-law, civil engineer S. A. Reed, he returned to New York City to establish himself as a consulting engineer. Once in New York, Parsons devoted a portion of his time to a new field of civil engineering, subway construction. He served on the engineering staff of two companies, The New York District Company and the City Railway Company, which sought, unsuccessfully, to construct underground rapid transit railways. While neither the District nor the City Company succeeded in constructing its underground road, Parsons gained valuable experience and a thorough knowledge of Manhattan's geography and transit needs.²

In October of 1886 Parsons left New York to serve as Chief Engineer for the Fort Worth and Rio Grande Railroad. He did, however, retain his affiliation with the District Railway Company.³ In 1887 he became the Chief Engineer and General Manager of the Denver Railroad and Land and Coal Company.⁴ Upon the completion of these railway projects and a number of water-works ventures in Mississippi, Parsons returned to New York in 1891.⁵

His reputation as a railroad engineer, his experience with the City and District Companies, and his past association with iron-maker and New York Mayor Abram Hewitt,⁶ made Parsons a logical choice for appointment in 1891 when the New York City Board of Rapid Transit Railroad Commissioners chose an engineering staff to design the specifications for an underground railway. He was made assistant to the Chief Engineer, William Worlen, a past President of the A.S.C.E. When, however, private capital neglected to bid seriously on the proposed franchise the plan was abandoned and both Parsons and his chief, the sole professional experts

on the Commission, were dismissed.

In 1894, a second attempt to finance an underground rapid transit railway was made by a reconstituted Board of Rapid Transit Commissioners. This time, Parsons was appointed Chief Engineer. He modified the 1891 plans, proposed a four track, electrically powered underground railroad located close to the street surface, and spent the latter half of 1894 defending the feasibility of the proposal.⁷ He made frequent appearances before a special commission empowered by the Supreme Court to investigate the practicability and desirability of the underground railway. Confident and articulate in defending the proposed subway, he rapidly answered the technical questions addressed to him during the commission's public hearing, and impressed even those opposed to the line's construction.⁸

Negative legal decisions, economic uncertainty, and the outbreak of the Spanish American War, however, impeded the line's construction. Parsons spent 1898 and 1899 surveying rail lines in China. In 1899, when approval for the New York to supervise its construction.¹⁰ At the end of 1904, with the majority of contract one construction completed and a large portion of the subway in operation William Parsons resigned¹¹ as Chief Engineer of the Board of Rapid Transit Railroad Commissioners. Appointed to the Isthmian Canal Commission, he traveled to Panama as a member of the Committee of Engineers and urged the construction of a sea level canal rather the lock type subsequently constructed. Upon his return to the United States in 1905, he established a consulting engineering firm with Eugene Klapp, a former division engineer of the Board of Rapid Transit. The Steinway Tunnel, a railroad tunnel beneath the East River, connecting mid-Manhattan, (34th Street) to Queens, financed by August Belmont, was the firm's first project. Saint John Clarke, another former Board of Rapid Transit division engineer, assisted Parsons in supervising the tunnels' construction. In 1905, Parsons accepted the position of Chief Engineer of the Cape Cod Canal, whose design and construction he supervised over the next nine years. Other projects undertaken by Parsons after constructing the New York subway included hydroelectric plants throughout the eastern United States; urban and interurban transit studies for San Francisco, Detroit, Baltimore, Chicago, Philadelphia and other American cities; and a bridge, dock, and land reclamation study in Cuba. Parsons also found the time to write American Engineers in France, a chronicle of his experiences as a military engineer during World War I, Robert Fulton and the Submarine, and a multi-volume Engineers and Engineering of the Renaissance. Parsons died on May 9, 1932.¹²

As a civil engineer, William Parsons numbered among the elite of the profession. Early in the 19th century, the precise functions of the civil engineering profession were undefined, and civil engineers were often craftsmen/entrepreneur rather than highly specialized and professionally -- trained experts. The engineers of the early canal and railroad

construction projects were practically trained men whose responsibilities "involved propriety and managerial functions in addition to the strictly technical..."¹³ The rapid growth in the number of engineers during the second half of the 1800s forced a redefinition of the traditional relationship between the engineer and society. Founded in 1852, the American Society of Civil Engineers had become by the 1870s the recognized professional engineering organization. By the turn of the century, with the aid of the A. S. C. E., the modern engineer had emerged.

The civil engineer of 1900, was ideally, well educated, cultured, and imbued with a sense of social responsibility. Whether he supervised the building of railroads, the tunneling of sewers, or the construction of aqueducts, his jobs were large, socially significant, and often publicly financed projects.¹⁴

New York's underground rapid transit railroad was just such a project. Other means of transportation existed in the city surface and elevated lines, but they had originated as short stretches of track, expanding and consolidating to form the systems evident in 1900.¹⁵ The subway system was conceived on a large scale from the start. It was to serve the entire length of Manhattan and parts of the Bronx, connecting not one avenue to the next, but linking distant communities. The social repercussions of such an undertaking were likely to be proportional to the enormity of the project itself.¹⁶

Parsons, associated with this municipally sponsored project from 1891 until his resignation in 1904, keenly felt the social implications of his role as Chief Engineer. In March of 1905, one half year after completion of the first part of the IRT, he delivered an address at Purdue University entitled "Rapid Transit in Great Cities," which reviewed several of the most recent and significant transit projects, including New York first subway. He argued that America's 'myth' of the practical man, the enthusiastic individual battling the odds, was outdated. The socially significant engineering works of the day, he said required "something more in the way of a foundation than an enthusiastic dream,... there is needed from the beginning the cold analytical methods of a trained and educated mind."¹⁷

Parsons envisaged an educated professional engineer: "The engineer of today, and more especially of the future, will...be concerned not only with his calculations, but will also have to study men and their needs, questions of industrial demand, the law of finance, and much in regard to legislation. His it will be to conceive, to plan, to design, to execute, and then to manage."¹⁸ The education of the engineer was to equip him, in short, to do it all. The engineer was, unlike other workers, to manage the fruits of his labor.

Parsons' conception of the engineer, demanding a mastery of numerous social sciences, underscores the emerging sense of the delicate yet vital relationship between engineering and broad social problems. The stress was on the project and on its designer/manager. The engineer, rather than the financier or workman, was society's ultimate benefactor.

The engineer was the advocate of efficiency, and for this reason Parsons deplored the wasteful competition of the numerous private companies undermining the success of rapid transit in London. In Paris, on the other hand, he saw "monopoly working smoothly for its own advantage and the public benefit..."¹⁹

This social awareness, a vague commitment to the public good combined with a sense of leadership and responsibility, was shared by many of Parsons' professional contemporaries.²⁰ Benjamin M. Harrod, in his presidential address to the American Society of Civil Engineers, predicted that civil engineers would be the leaders in the state of the future. H. G. Prout, editor of Railroad Gazette, told the 1899 graduating class of Stevens Institute that engineers might serve by virtue of their professional training, as correctors of human depravity as well as designers of structures. George S. Morrison, in 1903, disparaged "Yankee ingenuity" as a progressive force. His view of the scientific training and analytical ability demanded of engineers tallied nicely with Parsons'. Charles F. Scott, a prominent electrical engineer, wrote in 1904 that the young engineer was entering the profession "at a time when social and industrial affairs are in the middle of great changes, and at a time when the work of the engineer is most fundamentally and intimately related to these great movements."²¹

These prominent engineers did not, in their public addresses, tie their sense of social obligation concretely to specific engineering works. They pictured themselves as the planners, managers, leaders of society, with visions and duties extending beyond individual projects.²² Parsons' work on the New York rapid transit subway allowed him to translate his more general belief into practice.

Three principle factors guided and shaped the work of the Board of Rapid Transit Railroad Commissioners: a particular vision of rapid transit; the acquisition of a large, well-trained engineering staff; and the organization of the engineers into two distinct groups, the staff of the Commission and the staff of the Rapid Transit Subway Construction Company. High speeds along an independent right of way covering great distances were essential to the Board's view of rapid transit. All planning and implementation of the system would have to be done with these objective in mind.²³

Parsons wrote in 1905 that an engineer "...is more valuable... in proportion as he can successfully master all the elements of his problems."²⁴ The work was to be approached broadly, because a narrow frame of reference would result in a product ill-suited to its intended use. Parsons' 1894 report for the Board, Rapid Transit in Foreign Cities, exemplified this broad outlook. It analyzed the different transit systems within their own physical and social contexts, evaluating their applicability to other cities with a consideration of the different needs and aims in each individual situation.²⁵ Parsons did not examine street railway system, only tunnel or elevated roads providing rapid transit on exclusive rights of way. Nor did he confine himself to the examination of a particular type of motive power. The purpose of the Board,

as Parsons saw it, was not to tunnel a road and run electric cars through it. Its purpose was to establish a system of rapid transit for a significant urban area, with the particular needs of New York City in mind.

The credentials of the engineering staffs of the Board and the IRT met Parsons' high standards. Parsons' Deputy Chief Engineer, George S. Rice, served as Chief Engineer for the Boston Rapid Transit Commission between 1891 and 1892, and made extensive investigation and reports. Parsons and Rice, after years of study of rapid transit systems in intimate relation to the specific urban environment, were well suited to direct New York City's rapid transit project in accordance with the Board of Rapid Transit's broadly conceived plan.

Building the subway rapidly and economically required that construction be started at as many places as possible. To ensure that the materials used complied with the contract specifications and, supervising the diverse and often geographically scattered worksites required a large and effectively placed staff of engineers and inspectors. "For the convenience of superintending the construction... five engineering divisions were established. Each engineering division was supervised by a Division Engineer. One division, the sewer division, was responsible for supervising the contractors employed to excavate, relocate, and reconstruct all sewers and drains to be disrupted by the subway. The other four divisions corresponded to the four geographical sections listed in the construction contract. A Deputy Chief Engineer was appointed to assist in directing the work of the large staff of draftsmen and inspectors. A Bureau of Inspection was established responsible for to test and inspect materials at the point of production. Dozens of inspectors and assistant engineers monitored the actual construction."²⁷

Final authority for the design and construction of the subway rested with the engineers of the Board of Rapid Transit.²⁸ The contractor and sub-contractors also employed an engineering staff. The contractor appointed a Chief Engineer and General Manager, the latter to "lay out a scheme for the operation of the road and the acquisition of the necessary equipment."²⁹ The contractor also employed an electrical engineer, a mechanical engineer, and a car designer, "all particularly eminent in their several specialties."³⁰ Because of the size of the project the contractor divided the route into fifteen sections and enlisted subcontractors to perform the actual construction. Each of the subcontractors employed a civil engineer responsible for directing the work on his particular section and implementing the directives of the engineers of the Board of Rapid Transit.

The composition of the Commission's engineering staff was rich in technical school graduates. Parsons' belief in the necessity of a broad engineering education was of course not the only factor bearing on staff selection; the large percentage of graduates may simply have reflected the greater number of men preparing for engineering careers in such schools.³¹ But, Parsons' supervision of personnel selection doubtless contributed to the highly professional character of his staff. Like him, 27 of his 117 original engineers, were Columbia

graduates, George S. Rice, the Deputy Chief Engineer was a Harvard graduate. Among the division engineers, Beverly R. Value represented Columbia; William A. Aiken held a BA from Loyola and a degree in civil engineering from Rensselaer; and Albert Carr was a Yale graduate. Of all division engineers and assistant engineers, 100 of 118 were college graduates. Among the rodmen and axemen of the surveying staff, 73 and 37 respectively were graduates of a college.³² Position below the level of Division Engineer were filled by competitive Civil Service examination, but many of those holding these positions were also technically trained men. Both the popular and the engineering press found this information worth comment.³³

The credentials and backgrounds of engineers attracted to the consulting positions and to the service of the Rapid Transit Subway Construction Company, were no less impressive. Louis B. Duncan, of Duncan and Hutchinson, the electrical consultants to the Commission, held a doctorate from John Hopkins University. During his tenure as consultant to the subway project he was appointed chairman of the electrical Engineering Department at Massachusetts Institute of Technology.³⁴ In supervisory positions on the Rapid Transit Construction Company staff, S. L. F. Deyo, the Chief Engineer, and John Van Vleck designer of the boiler and operating plant of the subway power house, were both Union College graduates. Lewis B. Stillwell, the electrical engineer, held an engineering degree from Lehigh, and George Gibbs was a Stevens Institute graduate.³⁵

While the construction of the New York rapid transit subway was a major engineering project, it was also a business venture. The end product was to be a commercially profitable rapid transit railroad. August Belmont, financing the venture, took an active interest in the recruitment of the engineering staff of his construction and operating companies.³⁶ One of the earliest recruited was E.P. Bryan, superintendent of equipment and later general manager of the Interborough Rapid Transit Company. Through without an engineering degree, he had vast railroad experience, beginning as a telegraph operator and advancing to General Manager of the Terminal Railroad Association of St. Louis. His most noteworthy achievement was the supervision of the Union Station in that city. He brought managerial and business expertise to the Interborough Company, qualities useful to financier Belmont.³⁷ Bryan's early arrival may also have enabled him to advise Belmont in the selection of other railroad engineers.

Solomon F. Deyo, Chief Engineer of the Rapid Transit Subway Construction Company, also came to the Interborough Rapid Transit Company from steam railroading. After graduation from Union College, his railroad work was interrupted only briefly when he served as superintendent of the American Metaline Company, a manufacturer of dry lubricants. He then joined the staff of the Buffalo and Geneva Railroad and later worked for the New York, New Haven, and Hartford Railroad.³⁸

Among the electrical and signaling engineers, Lewis B. Stillwell and George Gibbs stand out as significant designers and innovators. Stillwell's background and experience was remarkably suited to his work on the subway. He joined the Westinghouse Electric and Manufacturing

Company staff in the 1880s and by 1895 was an assistant manager. He joined with engineer and scientist O. B. Shallenburger and William Stanley in research on alternating current technology. The extensive hydroelectric project at Niagara Falls in the 1890s was one of the first great ventures in alternating current transmission,⁶⁹ and when Westinghouse took the contract for the electrical equipment, Stillwell took charge of production and installation. In 1895, he left Westinghouse to become electrical director of the Niagara Falls Power Company and the Contract Construction Company.

The Niagara project publicized the possibilities of alternating current transmission. While at Niagara, Stillwell took on consulting assignments at other power and railway installations. Most important of these, with reference to his later work on the subway, was his job as electrical consultant to the Manhattan Railway Company during the electrification of its elevated lines between 1899 and 1902.⁴⁰ His experience on this project proved of great significance in the selection and design of an electrical system for the subway as the subsequent electrical engineering report will show.

George Gibbs' first job after his graduation from Stevens Institute in 1882 was at Thomas Edison's Menlo Park laboratory. He was involved in the early operation of Edison's first central electrical generating station at Pearl Street in New York. In 1895, he worked for the Chicago, Milwaukee, and Saint Paul Railway as head of the testing department, performing chemical and physical analyses of materials for railroad car construction. His work with this road, which included designing and occasionally patenting steam heating and electric lighting system for railroad cars and improved signalling systems, brought him to the attention of George Westinghouse. Westinghouse was just entering the direct current railway field and Gibbs became his representative in Europe. In this capacity, Gibbs took charge of the electrification of the Mersey Tunnel in Liverpool, England, and was a consultant to the Paris underground railroad. His consulting work for the New York Subway, involving supervision of rolling stock, tracks, switching, signalling and repair shops, drew on this rich experience. In New York, Gibbs continued his career as inventor and innovator, designing a trip for the automatic safety brake for the subway, and latch mechanisms for the sliding doors adopted for the rolling stock. With the cooperation of both the Interborough Company and the Pennsylvania Railroad, Gibbs designed the first all steel passenger cars used in heavy railroading. He introduced them into subway service, and the design was soon adopted by the Pennsylvania and the Long Island Railroad Companies, and their use quickly became standard railway practice.⁴¹

The most prominent engineers on the staffs of the Board of Rapid Transit Commissioners and the Rapid Transit Construction Company had experience primarily with steam railroads on electrically operated elevated, tunnel, or trunk lines. None of those considered above had

experience in electric street railway work. The experience of men in the heavy, high speed lines offered more to the projects than could those experienced with smaller, slower surface lines. The common thread which wove their efforts together was the desire of the Board, and especially its Chief Engineer, to provide New York City with a transit system characterized by a rapidity and convenience unknown in other major cities. The "Contract One" New York subway was to be the model for, and basis of, a system of underground rapid transit whose periodic expansion could serve the City's constantly growing population.

1. Engineering News and American Contract Journal, II, #14, October 24, 1885, p. 226.
2. "Memoir of William Barclay Parson," Transactions of the American Society of Civil Engineers, vol 98, 1932, 1485; "William Barclay Parsons," The World's Work, VI, #1, May 1903, p. 34-67-68.
3. Engineering News and American Contract Journal, XVI, October 16, 1886, p. 251.
4. Engineering News, (hereafter EN), XVIII, May 21, 1887, p. 336.
5. "Memoir of William Barclay Parsons," 1485.
6. Letter of May 2, 1888 to William B. Parsons from Abram Hewitt, letterpress book, Mayoral Correspondence, three volumes, New York Historical Society.
7. "Memoir of William Barclay Parsons," 1486; "The New York Rapid Transit Railway, II; Six Years Labor for Municipal Rapid Transit," EN, XLVII, #6, February 6, 1902, p. 106; "William Barclay Parson," The World's Work, VI, #1 May, 1903, p. 3468.
8. New York Times, January 30, 1894, see also, New York Times, January 4, 8, 9, 14, 15, 19, 24, 29 for other testimony.
9. "William Barclay Parsons," 3468-70.
10. "Memoir of William Barclay Parsons," 1486.
11. Ibid.
12. Ibid., p. 1486-91.
13. David Noble, American By Design: Science, Technology, and The Rise of Corporate Capitalism, (New York: Alfred A. Knopf, 1977), p. 35.
14. The early years of civil engineering are treated in Daniel H. Calhoun's, The American Civil Engineer, Origins and Conflict, (Cambridge, Mass: 1960). Calhoun feels that civil engineering crystallized early in the 19th century, and only well before the Civil War can one detect organization and roles significantly different from those of the modern period, (see his Preface, V-XII). Raymond A. Merritt, Engineering in American Society: 1850-1875, (University of Kentucky Press, 1969), stresses the civil engineers' professed social awareness, civic-mindedness, and cosmopolitan attitudes with a strong sense of social service. Specific examples are found in Merritt, pages 8-9, 131-150, p. 157-176.
15. See section 1 of this report.

16. James K. Finch, Engineering and Western Civilization, (New York: McGraw Hill, 1951), p. 231-234.
17. William Barclay Parsons, "Rapid Transit in Great Cities," (hereafter RTGC), address delivered at Purdue University, March 13, 1905, 2. Parsons wrote, "The mistakes of the practical man, pardonable in small things, are too costly."
18. Ibid.
19. Ibid., p. 22.
20. See Merritt, p. 7-8. He suggest that civil enigneers generally tended to be anti-competition. See also Monte A. Calvert, The Mechanical Engineer in Amercia: 1830-1910, (Baltimore, 1967). Calvert writes, "By the turn of the century, educators and publicists were suggesting that the engineer, was especially fit to deal with the problem of society," p. 269. Calvert stresses that civil engineers felt this far more acutely than did mechanical engineers, who shied away from the "large role" in society.
21. Benjamin Harrod, "Address to the Annual Convention," June 30, 1897, A.S.C.E. Transactions, XXXVII (1897), p. 539-41, cited in Merritt, 206; H.G. Prout, address reprinted as "The Engineer and His Country," Wisconsin Engineer, III (January, 1899), p. 77-78, cited in Calvert, p. 269; George S. Morison, "The New Epoch As Developed by the Manufacture of Power," New York, 1903, p. 93, cited in Merritt, 61; Morison's 1895 Presidential address to the A.S.C.E., Transactions XXXIII (1895), p. 483, cited in Calvert, 199; Charles F. Scott, "The Young Engineer," The Electric Club Journal (May, 1904), p. 198-204.
22. Calvert writes that the interest of many civil engineers in urban planning and reform resulted in the late 19th century visions of a "sort of technocratic system" (206) staffed by engineer administrators.
23. See Board of Rapid Transit Railroad Commissioners' Report 1900-1901, 185-186; also New York Times, January 8, 1896, p. 4-5. This theme, the Board's special notion of rapid transit, will be explored in greater detail in the electrical introduction.
24. Parsons, "RTGC," p. 2.
25. Parsons, Rapid Transit in Foreign Cities, (hereafter RTFC), 1894.
26. See "Report of the Chief Engineer," contained year in the annual Board of Transit Railroad Commissioners Report, Details of the work of the Inspection Bureau appear in 1900 1901, p. 252-258; 1902, p. 284-292; 1903, 188-197, 1904, p. 303-315; 1905, p. 166-175; 1906, 232-243; see also, "The New York Rapid Transit Railway, XI; Inspection of Cement," EN, XLVIII, #13, September 25, 1903, 242-244.
27. Contract between the Board of Rapid Transit Railroad Commissioners and John B. McDonald, "Agreement for Construction," 1899.

28. "Report of the Chief Engineer, 1900-1901," p. 209.
29. Ibid.
30. Calvert notes, page 52, that by the 1890s the "education of engineers was becoming a profession on itself." He was discussing, of course, mechanical engineering primarily. However, while practical experience was undoubtedly valued in engineering instruction, the time was past when virtually the only "schools" for civil engineers were the great public works, (see Calhoun, p. 25-53).
31. "Report of the Chief Engineer, 1900-01," p. 208, contains a "Table of Engineering Staff Education Statistics." Among schools with more than two graduates, the breakdown was as follows: Columbia, 27; Harvard, 10; Cornell, 9; Cooper-Union, 5; Rensselaer, 5; M.I.T., 4; Union, 4; Lehigh, 4; and Yale, 3. Of the 45 graduates among the rodmen and axemen of the surveying staff, 19 were from Cooper-Union.
- 32.
33. Technology Review, 4 (April, 1902); National Cyclopedia of American Biography, (N.C.A.B.), p. 14 (New York: 1910), 145-146.
34. New York Times, October 28, 1904, in August Belmont's scrapbook, Museum of New York. References to Construction Company are scarce. Six of the 38, excluding the four mechanical engineers, had "Memoirs" in the Transactions of the A.S.C.E., five of them were graduates. School represented were Stevens, 2; Rensselaer, Union, and . It does not seem justifiable, however, to generalize about the educational background of the Construction Company's engineering staff from this data.
35. "New York's Great Underground Railway," The Tramway and Railway World, p. 16 (November 10, 1904), p. 447-464. The article states that Belmont had a great deal to do with the selection of subordinates and engineers.
36. New York Times, October 28, 1904, August Belmont scrapbook, Museum of the City of New York; biographical information on Bryan in N.C.A.B., p. 11 (New York, 1901, 1904), p. 283.
37. N.C.A.B., p. 24 (New York: 1940), p. 204-205.
38. See Harold C. Passer, The Electrical Manufacturers, (Cambridge, Mass.: 1953), p. 276-295, for a discussion of the Westinghouse commitment to alternating current and the significance of the Niagara project.
39. N.C.A.B., p. 14 (New York: 1910), 520-521.
40. N.C.A.B., Volume E, (New York, 1938), 120-121; see also Samuel S. Watkins, George Gibbs, supplement 2, (New York: 1958) p. 231-232. Further information on both Stillwell's and Gibbs contribution will appear below in discussions of the power house and rolling stock.

The idea of underground railway transit had fascinated civil engineers as early as the 1850's. The first passenger carrying underground railway, the Metropolitan Railway, was built in London, 1860.¹ The first section of the Metropolitan was completed in January, 1863.²

The Metropolitan and the later Metropolitan District Railway operated beneath public streets and private property. The two roads travelled through shallow open cuts and in brick arch tunnels. A special construction, "masonry side walls and iron cross girders with brick jack arches turned between them," was used wherever it was necessary to reduce the height of the tunnel.³ Only a small portion of the railway, was built by tunneling. 'Cut and cover' construction, in which the railway structure is built in an open excavation, with the surface later restored to its original condition, was used almost exclusively in constructing the Metropolitan and Metropolitan District Railway.⁴ Steam locomotives propelled the trains on both lines, no mechanical system of ventilation was used in the tunnel portions of the railway. To compensate for the lack of adequate ventilation, "condensing" type steam locomotives, burning only sulfur free coke, were used.

The early (technical and financial), success of London's underground railway spawned a multitude of proposals for railroad transit beneath the streets of Manhattan. The American proposals were little more than imitations of the London Metropolitan Railway, a masonry arch tunnel built at a depth of between twenty-five and thirty-five feet below street.⁶ As these first schemes were never realized, engineers suggested other types of underground transit design. The two most common of these alternative designs were the deep tube tunnel and the close to the surface or "Arcade" railroad. During the years between 1864 and 1896 the feasibility of each of these types of underground railroads was continually debated as each new underground railroad plan was proposed and then abandoned.

In 1864, H. B. Willson proposed the construction of a five-mile long rail road, partly in tunnel and partly over ground, running between the Battery, on the southern tip of Manhattan, and an unspecified location near Central Park. A major portion of the double track, steam powered railroad was to be constructed in a tunnel beneath Broadway. Willson proposed constructing the tunnel under Broadway, "there being found, on careful examination, no engineering difficulties of any moment in the way."⁷ The "Metropolitan" or "Underground Railroad" as Mr. Willson labeled his proposed railroad, was to provide local and express service. Trains, operated at a speed of twenty to twenty five miles per hour, were expected to cover the five miles between the southern terminus at Bowling Green and the northern station at Central Park in twelve minutes. Willson believed that railroad "when fully completed will be regarded as a work in point of utility and importance not inferior to the Croton Aqueduct"⁸ but it was never constructed.

Refined versions of the Willson's plan "were periodically offered. The 1866 version of the Underground proposed to run beneath Fifth Avenue and 59th Street. Fifth Avenue was chosen because, unlike the other north-south avenues, it did not have a large number of water and sewer pipes buried beneath it.⁹ Civil engineers were enlisted to design the structure and the specific steps to be taken to construct the line.

A. P. Robinson served as chief engineer for New York's "Metropolitan Railroad."¹⁰ The design advanced by Robinson called for a brick arch tunnel whose crown was to be approximately eight feet below the street and thus well beneath the water pipes and sewers. The tunnel was to be twenty-five and one-half feet wide and sixteen feet high at the center of the arch. The tracks were to be twenty-four feet from the street. Ventilation was through pipes running between the tunnel and the street. Drainage presented "no particular difficulties".¹¹ Passengers were to ride in cars nine feet wide and forty feet long at a speed of twenty miles per hour between stations located at intervals of one half mile. Each car was to be capable of transporting eighty passengers. The sponsors of New York's Metropolitan Railroad estimated that three years would be needed to complete the project. Work was to commence at several points simultaneously to expedite the construction of the road.¹²

The Chief Engineer of the Croton Aqueduct, W.S. Craven, vigorously objected to any excavation necessitating the relocation and reconstruction of Croton water mains. He was certain the excavations would sever sewers and interrupt water service.¹³

Countering Craven, the sponsors of the Underground argued that the open methods to be used in constructing their line had been proven safe in constructing the London Underground Railway, which ran through streets more heavily laden with fragile pipes than any street in New York. In constructing the railroad, "not a single experiment is proposed or to be attempted" concluded the Underground's directors.¹⁴ Engineer Robinson, however did admit that some problems would be encountered in building the railroad. Canal Street, was "the real engineering difficulty."¹⁵ In crossing Canal Street, the Railroad would bisect the sewer outlet to the North (Hudson) River. Robinson proposed building new sewers that would recognize the Underground Railroad as the dividing line between the east and west side drainage systems. The construction of the Underground Railroad would require that the sewers be rebuilt so that henceforth all sewers east of the railroad would drain into the East River and those sewers on the west side of the line would flow into the North (Hudson) River.¹⁶

The fear of a massive disruption of street traffic during the construction of an underground railroad was a powerful objection frequently used against the proposed line. To minimize the inevitable disruption of street traffic, Robinson suggested that the tunnel be constructed in four separate stages. First, a trench would be dug and sheet piling erected to hold back the earthen walls. In this narrow trench the foundation and one sidewall would be constructed. Upon completion of one sidewall, the second wall would be constructed in an

identical manner on the opposite side of the street. Once both sidewalls were in place and covered with earth so that traffic could again travel above them, the middle of the street could be excavated and the arch between the sidewalls built while traffic was detoured to the sides of the street. With the arch completed, the street could be backfilled and repaved while the construction of the invert or bottom of the tunnel proceeded without interruption. Where this method of construction proved impractical, wooden bridges were to be built covering the entire excavation and allowing traffic to travel as usual, while the excavation of the entire street took place beneath.¹⁷

The Central Underground Railway made the second attempt to construct an underground railroad in 1868. The Central proposed constructing a steam powered railroad running beneath Broadway from City Hall north to Astor Place and then up Fourth Avenue to Union Square. From Union Square the line was to travel beneath Madison Avenue as far as 120th Street.¹⁸ To "inspire the public with confidence in the success of the undertaking,"¹⁹ the directors of the Central Underground Railway relied heavily upon the expertise of British underground railroad engineers. Two of the directors, George Griswold and William Ouncan, toured London's Metropolitan Railway, consulted with the engineers of the line, and contracted with the Metropolitan to import an engineering staff to direct the construction in New York.²⁰

In 1869, the Central Underground reported that the examinations conducted by their engineers had removed "every obstacle that had been supposed to be in the way." With the questions of grades, lighting, tunneling and ventilation solved, construction could begin as early as February, 1870. Ventilation was no longer to be a problem as the Central intended to use a rather mysterious, "new motive power, which the engineers recommend for use in propelling the trains, dispensing with steam and smoke and much of the noise caused by running locomotives."²¹ To expedite construction the railroad was to be built by a number of contractors, each undertaking a half-mile section simultaneously. Five thousand men were to be employed so that the work could be pushed forward by day and at night. Disruption of street traffic was to be kept at a minimum, "the earth being drawn out on over a thousand carts during the night while the streets are unobstructed."²²

While the proposals of the Metropolitan Underground Railroad and the Central Underground Railway were looked upon favorably for their promise to substitute "steam power for horse power,"²³ in their conveyance of passengers, their reliance upon British designs and construction methods prompted a measure of criticism. In New York Times cautioned that "... it is a very great mistake to regard the experience of London as conclusive for us in this matter or to assume that the success of an underground in that city demonstrates the feasibility and success of an underground railroad here. The conditions in the two cases are widely different, as are the object which the two roads are intended to service. The Metropolitan road is underground for only a portion of its length for the larger part it is simply an open cutting."²⁴

A third and significantly different underground railroad proposal was advanced by the New York Arcade Railroad. The Arcade Railroad differed from the New York Metropolitan and Central Underground Railroad primarily in the type of structure to be built and in the depth of its location. The Arcade Railroad Company proposed a shallow excavation of Broadway to a depth of fifteen feet. At this depth a subterranean street would be built within the curb lines of the street above. Upon this subterranean street a four-track steam powered railway was to be constructed. The railroad was to be bordered by sidewalks and stores occupying the basements and vaults of adjacent buildings.²⁵

By 1870, the Arcade Railroad boasted that its revised plans had "the unqualified and unanimous support of Broadway property holders who have taken the time to study it."²⁶ To reduce the noise and vibrations, the revised plans of the Arcade Company called for the tracks to rest on a "longitudinal section of rubber or other elastic substance." To allow street traffic to move smoothly the Arcade Company planned to use movable wooden bridges to fully cover the excavation.²⁷

The first actual construction of an underground railroad in New York began in 1869. Alfred E. Beech, the editor of Scientific American, proposed a pneumatically propelled railroad running beneath Broadway. In 1867, Beech demonstrated the feasibility of his concept of pneumatic transit, building a short wooden tube in which a railroad car carrying twelve passengers was propelled by a large fan located at one end of the tube. In 1869, Beech began excavating his tunnel from the basement of a building on Warren Street near Broadway. The Beech tunnel ran east from Warren Street to Broadway, where it turned at a 90° angle ran for one block beneath Broadway. Since Beech did not have a franchise to excavate beneath Broadway, the construction of his tunnel was carried out clandestinely for 58 nights. At the Warren Street end of the 312 foot long, 8 foot diameter tunnel, a large chamber housed a small station and a large blower for propelling the single passenger car. The car was circularly shaped and only slightly smaller than the diameter of the tunnel. The fan generated an air current that forced the car forward. A vacuum, created by reversing the fan so that suction discharged the air through an exhaust vent, permitted the car to be returned after it had been blown forward.²⁸

Beech opened his underground railroad to the public in February of 1870 and continued to operate it for almost a year, until pressure from some Tammany politicians forced its abandonment. The method used by Beech to construct his tunnel was almost as unique as his pneumatic railroad. Beech was the first American to use a hydraulically powered "shield" in driving his tunnel. The shield used by Beech permitted the tunnel to be driven without disturbing the surface above the tunnel. Eight iron shelves with sharpened edges formed a full circle the width of the tunnel. The material inside the shield was removed and a permanent cast iron or brick lining installed. While Beech used a relatively advanced method to drive his tunnel, his method of aligning its course was considerably less advanced. Each night, Beech aligned his tunnel by driving a jointed rod up through the roof of the tunnel and through the street where he could view it.²⁹

In 1873, at the urging of prominent civil engineer Octave Chanute, the American Society of Civil Engineers, established the "Committee on Rapid Transit and Terminal Freight Facilities." The committee investigated hundreds of designs for surface, elevated, and sub-surface passenger and freight railways.³⁰ Their report, issued in 1875, recommended elevated rather than underground passenger railways for Manhattan. Among their objections to underground railways were:

1. The roads could not be built and equipped much short of two or three million dollars per mile.
2. It would, during its construction, seriously interfere with the present surface traffic on the streets.
3. It would require expensive and inconvenient alterations of the sewer and of the water and gas pipes of the city.
4. At many points it would be below the high water mark and the cost of artificial drainage would add materially to the maintenance charges.
5. Ventilation would be difficult and expensive. (serious trouble already exists in similar tunnels although much shorter both in the vicinity and in London). The use of locomotive engines would make expensive mechanical ventilation necessary.
6. The patronage might be limited by the unwillingness of many persons to travel in tunnels and the operating expenses and maintenance be greater than above ground.³¹

One engineer, Charles H. Fisher, argued that the topography of Manhattan itself prohibited the construction of an underground railway. Concluded Mr. Fisher, "It is well known to those familiar with the topography of New York, that it is not at all suited to underground projects owing mainly to the low depression which crosses the City from North to East Rivers, in which there was formerly a canal."³² (A reference to Canal Street).

Despite the ASCE's endorsement of elevated rather than underground railways, civil engineers continued to offer designs for underground transit systems. The Harlem River Tunnel Company, which had proposed building railroad freight tunnels beneath Manhattan, and the remnant of the original Underground Railroad of 1864, joined, in 1880, to form the New York Underground Railway. The New York Underground Railroad proposed building two double track tunnels between Battery Park and Central Park similar in design to those suggested by the Underground Railroad between 1864 and 1866.³³

The Broadway Underground Railroad, the successor to the Arcade Railroad Company, also sought to build their railroad, using a modified version of an older design. In 1884 the Broadway Company obtained a charter to excavate Broadway to a depth of fifteen feet and construct a passenger transit railroad in the manner of the original Arcade Railroad scheme. The charter, however, limited the width of the excavation to thirty-five feet, insufficient for a four-track standard gauge railroad. To operate within the limits of their franchise, the Broadway Company proposed constructing not a two-track railroad, but rather, four narrow gauge tracks. Unlike the original Arcade Railroad, the Broadway proposed using either electricity or compressed air to operate their locomotives.³⁴ A year later the Broadway Company had committed themselves to using electric engines, but had moved no closer to constructing their line than any their predecessors.³⁵

In 1886, the New York District Railway obtained the right to construct a passenger railway beneath Broadway. The District Company proposed to build a line from Bowling Green at the southern tip of Manhattan north, beneath Broadway, to Madison Square. At Madison Square a west-side line was to branch off, run beneath Broadway and terminate at Eighth Avenue and 59th Street, while the main line continued up the east side beneath Madison Avenue, under the Harlem River and into the Bronx. The line was to be built with four tracks, so that both express and local service could be provided. The engineers of the District Company, with Parsons at their head, proposed to construct the line entirely beneath public streets and to use the existing curb lines. Water, gas and steam pipes, pneumatic tubes, electric cables, and sewers were all to be relocated in galleries constructed parallel to and adjacent with the route of the subway. The line was to be constructed by open excavation in small sections so as not to disrupt a large volume of surface traffic.³⁶

Plans called for the excavation of the line to be 16 feet deep and 35 feet wide, with an additional four and one-half feet on each side of the railway to be occupied by the pipe galleries. A foundation of concrete two feet thick, coated with a thick layer of "Trinidad" asphalt, was to be laid along the entire length and width of the line. The external walls, the partitions separating the railway from the pipe galleries, the track, and the columns supporting the roof girders, were to be built upon this foundation. The exterior walls were to be of brick masonry and the center columns were to be wrought iron, spaced four feet apart resting upon cut granite footing stones. Iron girders were to be placed transversely across the columns and a roof constructed from steel plates would rest across the girders. Upon these plates was to be placed a full two inches of asphalt waterproofing and a six-inch layer of concrete. The street pavement was to be relaid directly above this steel, asphalt, and concrete roof. A unique feature of the District Company design was the proposal to place between the iron columns a longitudinal partition of "steel wires interlaced with flax or vegetable fiber and oil compound, the whole pressed into a solid panel by hydraulic pressure." The Ferflax was expected to significantly deaden the noise produced by the electrically powered trains that were to utilize the tunnel. It was estimated that with the methods of construction to be used the cost per mile would not exceed three million dollars per mile.³⁷

The District Company, however, never obtained the funds necessary to begin construction.

The high cost of construction was not the only criteria used to question the viability of underground rapid transit. The Sanitary Engineer argued that a system of rapid transit would provide riders with a comfortable, rapid, and inexpensive ride that did not annoy residents adjacent to the route to travel. In looking at existing modes of urban transit, the Sanitary Engineer concluded:

"...it is certain that the requirements of rapid transit are not fulfilled by railroads on the surface of the ground... they are not fulfilled by iron-constructed-trestles built over public streets and too flimsily constructed to carry motors of sufficient power to draw the necessary loads, yet carrying machines which are so noisy in their operation as to be a frightful nuisance."³⁸

However, underground railway transit was seen as even less of a viable alternative than the surface or elevated lines. Even with the prospect of an electrically propelled underground railroad, the Sanitary Engineer concluded:

"Still less can the necessary condition of comfort and health be fulfilled by any subterranean structure, such as is suggested for Broadway. In London, where underground roads have been built and operated for several years, with all the efforts of the ablest men, theoretical and practical, to attain perfection, the testimony of the builders and managers of the roads so very strong to the effect that all their efforts to secure good ventilation have proved unsuccessful. In New York the discomfort of underground travel is abundantly proven to the thousands who pass daily through the tunnels and covered ways of the Fourth Avenue road (the street car line) from Thirty-fourth to Forty-First Streets...The health and safety of the public which are the 'supreme law,' demand... the keeping of the passengers above ground at any cost."³⁹

The City Railway Company offered New York another variant of underground rapid transit, one that promised to improve at the very least, the health and safety of those living above the route of the proposed railroad. The City Company proposed constructing an underground railroad through the middle of blocks, beneath private property. Once the four track line was constructed, new fireproof residential and office buildings would be constructed over the railway. Drawing upon the idea of the Arcade Company, the City Railway intended to construct their line as a shallow tunnel railroad with the track twelve feet below the surface of the street. Electricity was to provide the motive power for the line. The City Railway Company anticipated that building its four tracks line and restoring the surface with five story fireproof buildings would cost approximately \$3,500,000. per mile.⁴⁰

Less than one month after the City Railway proposed its novel form of underground transit, an underground railroad unlike any previously considered, a deep tunnel line, was proposed by a New York City construction contractor. The route of this deep tunnel railroad was also unlike any previously proposed. The line was to begin in the Bronx, cross into Manhattan and, buried deep beneath Central Park and Fifth Avenue, continue south to Washington Square. A Washington Square line was to proceed to City Hall Park where it would divide, one line turning west and crossing into Jersey City, New Jersey, (where it could connect with the large terminals of large trunk railways) while the other branch continued south to the Battery. From the Battery the railroad line was to cross into Brooklyn and emerge as a surface road at Prospect Park, continuing above ground to a terminal at Coney Island.⁴¹

The Tunnels were to be driven at a depth of 150 feet below the surface. Elevators were to transport passengers between the street and the tunnel stations. Asked why he had chosen to propose a deep tunnel rapid transit railway, contractor Clarke responded:

In order to avoid steep grades and to get a perfectly unbroken solid sub-stratum of rock in which to work. Furthermore, at that depth the concussions and jars from explosions in mining will be hardly perceptible at the surface and therefore unobjectionable.⁴²

Clarke did not specify whether steam or electric locomotives would power his underground railroad. He did indicate that mechanical devices would be employed to assure that the tunnels were adequately ventilated.⁴³ The deep tunnel proposed by Clarke was never constructed. His idea for a deep tunnel railway connecting Brooklyn and Manhattan with the major railroad terminals on the west side of the Hudson was, however, revised and subsequently championed by the Metropolitan Railway Company of New York in 1890.

While American Engineers were designing and proposing underground railway that were never built. European engineers were supervising the construction of subways that would provide model for the IRT. Between 1884 and 1900, steam powered underground railways, electric underground rapid transit railways, and electrically powered elevated railways were

constructed in London and Liverpool; Glasgow; Paris; and Buda est.⁴⁴

The City and South London Railway, begun in 1886, was a radical departure from previous London underground railway construction. Unlike the Metropolitan Railways, the City and South London was built as a deep tunnel. The three-and-a-half mile railway traveled in two cast-iron lined tubular tunnels located between forty and eighty feet beneath the streets of London. The deep tunnel construction necessitated the use of both stairways and elevators in the stations. The City and South London was unique for two reasons. First, the railway tunnels were driven using a circular shield in a manner similar to that used by Alfred Beech in driving his short tunnel beneath Broadway. Second, the City and South London, though designed as a cable railway, adopted electricity to propel its trains. Electric locomotives weighing between ten and a half and thirteen and a half tons pulled three-car trains up grades as steep as three per cent at speeds of ten to twenty-five miles per hour.⁴⁵

The completion of the City and South London Railway encouraged the construction of a number of similarly designed, electrically powered deep tunnel railways. The construction of the Waterloo and City Railway; Central London; Waterloo and Baker Street; and Charging Cross; Euston; and Hampstead added twenty-three and a half miles of deep tunnel railway to the London system.⁴⁶

In 1886, after three years of construction, the Glasgow City and District Railway began operation. The three-mile line was built by an equal mixture of cut and cover, deep tunnel, and open cut construction. A steam powered road with a conventional brick arch tunnel, the Glasgow line was unique primarily because construction began at twenty-two different locations.⁴⁷

The Glasgow Central, begun in 1888, used both brick arch and flat roof; iron girder construction. Because of the presence of large deposits of "mud, clay and sand, the latter generally saturated with water and frequently partaking of the nature of Glasgow's,"⁴⁸ Glasgow's second underground railway was built close to the surface and almost exclusively by cut and cover. The presence of a large number of sewer pipes in the path of the railway, and the desire of the municipal officials that construction not disrupt traffic, necessitated some imaginative construction techniques. Sewers that intersected the subway were rebuilt to travel parallel streets, and water and gas pipes that crossed the route were replaced by a larger number of smaller diameter pipes, easily relocated above or long the side of the railway structure. Municipal officials limited the interruption of street traffic by permitting open excavation only between 12PM on Saturday and 5AM on Monday. Compliance with this regulation necessitated excavating, erecting, and restoring as large a section of railway structure as could be completed in the forty-one hours allotted by the municipal government. Glasgow's construction of a shallow tunnel by means of open excavation through difficult terrain, with a minimum of interruption to street traffic, demonstrated that the subway construction need not be prohibited for fear of disrupting the daily life of the city.⁴⁹

The Liverpool Elevated Railway, provided further and more dramatic testimony to the economy of electrical propulsion. Using the most advanced electrical generating equipment and burning an inexpensive grade of coal provided "financial results... even more satisfactory than in London...."⁵⁰

In Paris, two steam railways provided local passenger service. The Chemin de Fer Ceinture, a twenty-mile long, two track belt railway, was built "according to the topography -- surface, open cut, tunnel and viaduct" construction being adopted. The Chemin de Fer de Sceaux, begun in 1891, while short in length (6,240 feet) provided a number of lessons in economical construction of sub-surface railway structures. Masonry arch tunnel; flat, iron girder tunnel; and open cut, comprised respectively 79, 15, and 5% of the line. Cut and cover construction was used extensively.⁵¹

In Paris, as in Glasgow, a unique method of construction was devised in order to reduce disruption of street traffic. Unlike Glasgow, where short sections of the whole structure were erected, the Chemin de Fer de Sceaux constructed longer sections of one half of the tunnel structure, leaving the other half of the street unexcavated. Where brick arch tunnel was used, one half of the street was excavated, the side wall and half of the arch constructed, and the street surface immediately restored. Shifting traffic to the completed side of the street, the other side was excavated, the remaining side wall built, and the arch completed. Once the arch was completed the core of earth left untouched beneath it was excavated using a railway constructed within the tunnel to haul it to a central hoisting structure. Where iron girders were used to build the structure, a similar procedure of erecting only one half the structure at time was also followed.⁵²

The engineers responsible for supervising the construction of the Chemin de Fer de Sceaux reported that it was both "better and cheaper to:

- 1) remove and introduce all material by train and not through the streets by wagon;
- 2) use simple material, especially concrete;
- 3) keep the rail level as close to the surface as possible, as the difficulties and expense increased with the depth."⁵³

The Budapest underground railway, completed in 1896, was the first underground railway to substitute steel for iron and concrete for brick. The Budapest line, like the American "Arcade" and "District" Railways, ran through a shallow tunnel with masonry walls and a flat roof. Unlike its projected flat roof predecessors, the Budapest line used steel beams in the roof between which concrete arches were formed.⁵⁴

While no American city had an underground railway comparable to those found in Europe, two American railroads, the Baltimore Belt and the Intramural of Chicago, contributed to the technical progress of rapid transit. The Baltimore Belt was constructed to allow the Baltimore

and Ohio Railroad to travel through Baltimore and cross the Partapsco River without using a car ferry. The critical portion of the seven mile, electrically powered railroad was the 8,350-foot section beneath Howard Street, one of Baltimore's most heavily traffic streets. Cut and cover construction was used for 1,200 feet while almost 7,000 feet was tunneled. The tunnel was a brick arch structure whose crown ranged from ten to fifty feet below the street.⁵⁵

The construction of the Baltimore Belt Railroad made a contribution to the future New York Rapid Transit Subway. It demonstrated that electric locomotives were capable of hauling heavy trains. The difficulty of constructing a tunnel railroad through water-laden sand, beneath a heavily traveled and built up street, necessitated that the contractor devise cautious methods of construction. The contractor who constructed the Baltimore Belt Railroad and gained this valuable experience was John B. McDonald.

The Intramural Railway of Chicago, a short (2,800 feet) elevated railway, was the first United States railway to use electricity to propel "fill trains run in a regular service." The success of the Intramural in 1894, prompted the Metropolitan West Side Railway of Chicago to choose electricity to propel their trains.⁵⁶

The construction of the European undergrounds demonstrated that "... it had become possible to use, with comfort and cleanliness, the great sub-surface for transit purposes, a space hitherto considered of value only as a place to bury sewers, water and gas mains in haphazard and disordered confusion."⁵⁷ European precedents encouraged American engineers to see that a practical and desirable alternative to the elevated railroad did exist. The introduction of electricity to propel the trains permitted the underground railway to be transformed into an underground rapid transit railway. Not only did electricity render ventilation less of a problem, but is also reduced the costs of operation. The introduction of steel and concrete provided engineers with an economical means of constructing large sub-surface railroad structures.

With all the evidence available from foreign and domestic examples, two factors emerged to determine which of the many types of underground railways was most appropriate for New York: the cost of operation and the cost of construction.

The operation of London's electrical underground railways, the Liverpool elevated, the Baltimore Belt Railroad, and the Intramural Railway of Chicago demonstrated that electricity offered the most economical means of propelling urban passenger trains. Electricity also permitted the trains to be operated in any type of tunnel, deep, intermediate, or shallow depth, where steam locomotives, because of the ventilation systems required, were restricted to the shallow or intermediate-depth tunnels. And since "the substitution of a motor other than an ordinary steam locomotive would at once remove 99.997% of the foul atmosphere from an ordinary railway tunnel,"⁵⁸ the cost of ventilation systems could be avoided.

Glasgow demonstrated deep tunnels were eight times more expensive than open excavation. Paris confirmed that cut and cover construction of the shallow depth tunnel was the most economical. The general hypothesis that emerged from the European experiences was that the deeper the tunnel the more expensive it would be to construct.⁵⁹ Additionally, the need for mechanical ventilation and elevators in the deep tunnel railway added to the cost of both construction and operation. The conclusion was that an electrically propelled railway built in a shallow or intermediate depth tunnel was both more economical to construct and operate.

Private capital's inability to construct an underground railway in New York prompted more active municipal involvement in the rapid transit decision. In 1891, Mayor Hugh Grant appointed a new Rapid Transit Commission the first in the city's history to have an engineering staff confined, as previously mentioned by William Worthen and William Barclay Parsons.

Charting the topography that the subway structure would encounter was the first step. Test borings were made along Broadway from South Ferry to 34th Street. The results of these tests were both unexpected and encouraging. The engineers learned that in general the presence of solid rock was at a depth greater than generally believed; they encounter rock until 163 feet beneath Duane Street in lower Manhattan. The rock beneath Canal Street, however, was closer to the surface than had previously been believed. And the material encountered at Canal Street was not "muck and fine sand, but on the contrary," consisted "largely of good, coarse gravel and presents an excellent material for foundations."⁶⁰

With the added knowledge devised from the borings, Worthen and Parsons proceeded to produce two differing proposals for a Broadway underground railway.⁶¹ Worthen offered a structure where all four tracks were located on a single level, while Parsons placed four tracks on a two-tiered, double track structure. Both Worthen and Parsons chose electricity as the motive power.⁶² Worthen envisioned a four track road built upon a concrete foundation. Iron columns would support a roof of wrought iron girders covered by iron plates. Upon this iron plate ceiling a layer of coal tar was to be placed to insure against water seepage and corrosion. The tunnel was to be built without interfering with the sub-surface sewers and pipes, because the roof of the structure was to be kept at least eight feet below the street.⁶³

Parsons prefaced his proposal with a general description of the problems to be anticipated in constructing a subway beneath the streets of lower Manhattan and a discussion of the alternatives that existed to overcome the impediments. He found the major obstacle to the rapid and economical completion of an underground to be the maze of pipes, conduits, cables, and sewers beneath the streets. He concluded:

There are two general systems by which it seems possible to construct a railway under Broadway without interfering with the pipes and wires; a tunnel in solid rock reached by elevators, or a tunnel midway between the rock and surface, driven through the sand by a shield.⁶⁴

The result of the test borings had strengthened the argument against the construction of a deep tunnel railway, indicating that certain points in the downtown area rock was as deep as 160 feet below the surface of the street. To build a structurally sound tunnel, boring through solid rock would be required. With the surface of the rock at such varying depths, the construction of a deep tunnel railway would have to be at so great a depth, in some places 200 feet below the street, as to be excessively costly both to construct and operate. Since a tunnel this deep would be inappropriate for a system designed for local as well as long distance travel, the alternative was to construct a tunnel through the deep layers of sand at a depth below the deepest pipe, or a tunnel that was located directly below the street, requiring relocation all pipes encountered during its construction. Parsons choose the latter alternative and explained the rationale for his choice:

As to tunneling through sand, while I believe it would be possible to drive such a tunnel, I also believe that the cost of doing so would be very excessive, and the risks run very great. The borings show that along a large portion of Broadway, especially where the buildings are the largest, and the traffic greatest, the sand is exceedingly fine, approaching, if it is not actually, a quicksand. In the space above the top of the tunnel are all the water mains and sewers; and if the slightest settlement takes place in the roof of the tunnel (which it would be almost impossible to prevent), a leak in the pipes would be almost inevitable; and as soon as sand should be charged with water the tendency to flow would be greatly increased, and a further settlement would follow. Not only is the weight of the sand above to be considered, but the weight of the enormous buildings along Broadway, which practically amounts to surcharging the soil, and also the street traffic, constantly settling up a jar or trembling of the sand and also increasing the tendency to run. If an accident should occur the loss might be so great to beyond the power of any company of contractor to make good. From Twelfth Street north the shield had to be driven partly through rock and partly through sand, increasing the cost and danger.⁶⁵

Parsons concluded a tunnel that avoided interfering with sub-surface pipes would be uneconomical to construct. He recommended the railroad be constructed as close to the surface as possible and all pipes encountered during construction be relocated in such a manner as to avoid the subway and still allow access for repairs. Specifically, Parsons called for the construction of a two-tier roadway, each with two tracks and a center gallery for all pipes. Parsons structure, like Worthen's was to be built on a concrete foundation, have iron columns and cross girder, and be topped by an iron plate roof covered with a protective covering of asphalt.⁶⁶

Both plans received considerable discussion in the popular press and among the engineering journals.⁶⁷ Four consulting engineers were chosen to evaluate the two plans and decided to Worthen plan the least disruptive of street traffic. However, despite the popular discussion and the endorsement of the consulting engineers the plan went no further than the paper upon which it was drawn.

Passage of the rapid transit act of 1894 inaugurated another attempt to construct a rapid transit subway. The 1894 Board of Rapid Transit Railroad Commissioners appointed William Barclay Parsons Chief Engineer, provisionally adopted the 1891 plan for a single level, four track subway beneath Broadway, and instructed Chief Engineer Parsons to investigate European rapid transit railways.⁶⁸

Upon his return from Europe, Parsons expressed disagreement with the route chosen by 1891 Rapid Transit Commission. He argued that since any construction beneath Broadway would provoke vigorous objections from adjacent property-owners, New Elm Street, an avenue parallel to and 100 feet east of Broadway, should be the route of the subway between City Hall and Astor Place.⁶⁹

The Board of Rapid Transit Railroad Commissioners appointed a Board of Experts to evaluate Parsons' proposal. The Board of Experts consisted of four civil engineers; Octave Chanute, Thomas C. Clarke, William M. Burr, and Charles SooySmith; and former Mayor Abram Hewitt. The five advisers endorsed Parsons objections to the 1891 route, approved his altered design and verified the accuracy of his estimates of the cost of construction.⁷⁰ The Board of Rapid Transit Railroad Commissioners, however, rejected the substitution of Elm for Broadway and accepted with minor modifications the 1891 plan of construction.⁷¹

On May 22, 1896, the New York Supreme Court denied the Board of Rapid Transit the authority to construct the subway along the Broadway route proposed in 1891. Having been denied the right to construct a rapid transit subway beneath Broadway, the Commission came round to the views set forth by Parsons and the Board of Engineering Experts. A resolution passed by the Commission shortly after the Supreme Court decision directed the Chief Engineer to:

... submit to this board at as early a date as possible routes and a general plan of rapid transit which shall conform to the following conditions:

1. Total cost after abundant allowance for contingency not to exceed \$30,000,000.
2. Route to proceed from the southern terminus at or near the Post Office and under the City Hall Park and Park Row to Elm Street and Fourth Avenue to or near the Grand Central Station, and there to divide into the east and west side routes. The west side route to proceed under 42nd Street to Broadway and the Boulevard to a point above 125th Street. The east side route to proceed under Park Avenue and over private property to the Harlem River and across and beyond the Harlem River to as distant a point as the proposed limit of cost will permit.

3. The railroad to have four tracks to the junction of the east and west side routes and above that point two tracks on each route, except for a third track for express service shall be added on both routes when conveniently and economically possible.

4. The road to be in a tunnel, except on the east side north of 98th St. and on the west side at Manhattan Valley, 125th Street.

5. Plans to be drawn so as to permit further extensions in the future from the south and north termini and permitting the two and three track portions to be widened into a four track system without unnecessary expense or interruption of service.⁷²

Within four months Parsons returned with a plan containing the modifications in compliance with the Court's objections to the 1891 plan. Parsons estimated that sufficient savings could be made if the portion between the Battery and City Hall Park were eliminated. The southern section of the line was placed beneath Elm Street, and the junction between the east and west side lines was moved from 14th Street to 42nd Street.⁷³

As part of his relocation report, Parsons conducted test borings along Elm Street. The borings indicated that "to the depth for which the excavation for the railway will be made, there was no material found which would slide or give difficulty in handling."⁷⁴ Rock at a level interfering with the subway structure was first encountered at 12th Street and continued north. It was during the Elm Street borings that tests for standing or ground water were first made. The tests revealed the ground water was found "about one foot above the level of the mean high tide."⁷⁵ Parsons found this information encouraging since it indicated that with the exception of the line between Leonard and Grand Streets, a distance of 1,600 feet, the Manhattan portion of the subway would be above the high tide, a level which made mechanical drainage equipment unnecessary. Since Elm Street lay near the City's drainage dividing line, the problem of relocating the sewers intersected by the subway would be considerably reduced an additional economic realized.⁷⁶

"... slow or difficult to build and the proposed route therefore escapes entirely the difficulties of construction which were present along Broadway incident to the heavy traffic, cable railways, complications of sub-surface structures, and the care of abutting buildings. The work can be attacked at once at as many places as can be conveniently operated at once."⁷⁷

Beyond the modifications presented, Parsons envisioned that the remainder of the route could be built in accordance with the earlier plan.

The Court approved this new proposal, subject to a number of financial conditions which were not met until November, 1899. This done, the Board of Rapid Transit Commissioners authorized the drafting of formal specifications that could be inspected by contractors interested in constructing the railroad. The route finally adopted called for the subway to begin, "at a point at or near the intersection of Broadway and Park Row,"

and proceed North beneath Park Row and Centre Street to New Elm Street. After traveling beneath Elm Street as far as Eighth Street, (Astor Place) the line was to proceed North beneath Fourth Avenue until Union Square (14th Street) was reached. From 14th Street to 42nd Street the road was to travel under Park Avenue. Upon reaching 42nd Street the line was to travel west beneath 42nd Street as far as Broadway. Between 42nd Street and 190th Street the route followed first Broadway and, after crossing 167th Street, Eleventh Avenue. North of 190th Street, Ellwood Street and Broadway were to carry the line across the Harlem Ship Canal and into the Bronx. An east side route was to diverge from the Broadway line at 103rd Street and proceed east under Central Park to the intersection of Lenox Avenue and 110th Street. The subway was to continue north beneath Lenox Avenue as far as 141st Street where it was to cross under the Harlem River and emerge as an elevated road, traveling via Westchester Avenue, Southern Boulevard, and Boston Road to the Northeastern terminus at Bronx Park.⁷⁸ . Diagram 177 illustrates the route of the subway.

The contract divided the construction into four sections, so that if funds for the entire line were unavailable, construction of a portion or portions of the line could begin. The four sections were:

Section 1 commencing at the southern terminus of the line at City Hall and continuing north to 59th Street. .

Section 2 beginning at 59th Street and proceeding north to the station at 137th Street.

Section 3 beginning at the north end of the 137th Street station and running along the west side as far as the station at Fort George and on the east side from 135th Street to Melrose Avenue.

Section 4 begin the remainder of the west side route, from Fort George to Kingsbridge and on the east side from Melrose Avenue to the Northern terminus of the east side line.⁷⁹

In November of 1899, the Board of Rapid Transit published an "Invitation to Contractors" formally soliciting bids for the construction of the proposed rapid transit subway.⁸⁰ Engineering journals criticized the format of the invitation. The Engineering News was convinced that no contractor was in a position to equip and operate the road as the contract specified. The Engineering Record argued that constructing the subway, "at a time when materials are unprecedentedly high" and in a city where the compliance with "state and city labor laws... considerably increases the cost of work," would diminish the enthusiasm of any contractor to bid on the project.⁸¹

Two contractors, Andrew Onderdonk, and John B. McDonald, did submit bids to construct and operate the New York rapid transit subway. Mr. Onderdonk and his son, a civil engineer, operated the New York Tunnel Construction Company.⁸² McDonald was a railroad and public works contractor who had performed construction work for the Baltimore and Ohio, Pennsylvania, West Shore and Potomac Valley Railroads between 1881 and 1889. In 1890, when the Board of Rapid Transit was first at planning the subway, McDonald began the construction of the Baltimore Belt Railroad, successfully completing it in 1895. At the time McDonald bid on the subway, he was working on the Jerome Park reservoir. In February, 1900 the Board of Rapid Transit announced that he had been selected to construct all four sections of the subway.⁸³

The size of the project, the variety of the structures to be constructed and the terrain to be worked, and the general desire to complete the project in as short a time as possible,⁸⁴ prompted the contractor to divide the project into fifteen sections, "the beginning and ending of these several sections being fixed by local conditions necessitating variations in the construction."⁸⁵ Individual sections were then placed under the jurisdiction of sub-contractors. Diagram illustrates the geographic boundaries of the fifteen sections and lists the sub-contractor responsible for each one. Steel erection all along the route was contracted to one firm, Terry and Trench Company. The work of relocating and reconstructing the sewers, the first step, was distributed among a number of small sub-contractors.⁸⁶

Two of the biggest contracts were for furnishing structural steel and cement. The Carnegie Steel Company undertook the manufacture of the 74,326 tons of structural steel and 4,000 tons of rail required to construct the subway. The contract required 22,439 tons of steel beam, 20,466 tons of rivet steel, 7,921 tons of steel column, 23,500 tons of steel viaduct, and 4,064 tons of rail. United Building Materials Company was awarded the contract to supply McDonald and his sub-contractors with 1,500,000 barrel (300,000 tons) of cement. In 1895, the total amount of cement consumed in the United States was less than 100,000 barrels. The largest portion of the cement was used in making concrete. Mixed with twice as much sand and four times as much crushed stone, the engineers estimated that 400,000 cubic yards of concrete would be produced for use in constructing the subway. These two contracts were "the largest ever undertaken by an individual firm for supplying cement and steel for a single engineering work."⁸⁷

The contract between McDonald and the Board of Rapid Transit consisted of ninety-four pages of basic construction specifications accompanied by three volumes of maps and drawings. The contract described not only the route and the type of construction to be followed, but also the specific materials to be used in constructing the subway, and methods of construction permitted.⁸⁸

The contract permitted open excavation (cut and cover) construction and tunneling. Open excavations were not to exceed 400 feet in length unless covered to permit the passage of pedestrians and vehicles. Open excavation was permitted between the southern terminus at City Hall station and 34th Street. Tunneling was required between 34th and 40th Streets and on the east side route from 104th Street, beneath Central Park, to Lenox Avenue and 110th Street. Open excavation was permitted along 42nd Street, and on the west side as far north as 60th Street. North of 60th Street the contractor could choose "the most expeditious manner possible, having due regard to safety of persons and property and reasonable consideration for the accommodation of street traffic."⁸⁹

Having studied the deep tube; intermediate depth, arches masonry and shallow, flat roof or "Arcade" style, the Board chose the latter Chief Engineer Parsons explained:

weighing all the advantages and disadvantages your Engineer recommended the adoption, so far as possible, of the shallow excavation type on account of the greater convenience when completed and probable less expense to construct...⁹⁰

The Board's preference for a shallow tunnel railway received tangible encouragement from the example of the Boston subway. In 1895, Boston began constructing an underground right of way for a portion of its electric street car line. Boston desired to decrease the congestion of its downtown streets and increase the rapidity of streetcar travel. To accomplish both objectives, the city decided that in the most congested area the streetcar tracks should be relocated beneath the street. To assure maximum accessibility, the "Arcade" or shallow depth tunnel was chosen. Like the recently completed Budapest railway, the Boston engineers used steel beams with concrete arches between them in constructing their flat roof tunnel. The Boston tunnel introduced steel columns with concrete arches between them into the side walls as well.⁹¹

In New York, however, "abrupt changes in topography and geological formation" prevented shallow construction everywhere. Between City Hall and 31st Street, 41st Street and 122nd Street, 135th and 150th Street, and beneath Lenox Avenue, the structure was built close to the surface. Between 33rd and 40th Streets, the presence of the Metropolitan Street Railway's Park Avenue tunnel necessitated dividing the subway and passing the tracks under Murry Hill in two separate concrete-lined tunnels. The need to "maintain reasonable gradients" also necessitated tunneling beneath Central Park between Broadway and Bronx Avenue, and on the west side, between 150th and 155th Streets, and from 158th Street to Fort George. Depressions of the topography required the construction of a viaduct between 122nd and 135th Streets. Topography and economics encouraged the use of an elevated structure on the west side, north of Fort George, and on the east side north of Melrose Avenue in the Bronx.⁹²

Different types of construction were used in building the subway. Drawing 167 indicates the multiplicity of tunnel structures used in the 20.5 mile route. The majority of the tunnel, 10.6 miles or 52.2% of the Contract One road, was constructed with a flat roof of steel I-beams and transverse concrete arches. A section of the standard steel frame tunnel is depicted in drawing 181. Steel I-beams, spaced five feet apart longitudinally, served as side wall columns and horizontal ceiling beams. Between the I-beams, concrete arches were formed. Photograph 131 illustrates the forms for the concrete roof arches and the shallow depth of the roof beneath the street. Photograph 14 illustrates how the concrete is poured to form the jack arches between the roof beams of the standard steel frame structure. In photograph 92 masons rub cement into pits and voids left after forming the poured concrete sidewalls. Above their heads are visible the concrete arch forms and steel-I beam wall columns. Four bulb-ended steel angles, six inches in width, were riveted together to form a single bulb-angle column. The bulb angle columns were placed between the tracks to carry the steel roof beams. Knee braces were used in connecting the bulb angle columns and the roof beams. Photograph 119 illustrates the placement and longitudinal spacing of the bulb angle columns, the use of I-beams in the roof and exterior walls, and the knee braces running diagonally between the roof beams and the bulb angle columns. The steel frame rested on a concrete foundation, the full width of the subway, with a minimum thickness of eight inches. Granite footing stones within the concrete foundation supported the bulb angle columns located between the tracks. The granite stones upon which the bulb angle columns rested are shown in photograph 125. The entire structure, top, bottom, and both sides, was coated with a thick layer of waterproofing. The eight layers of felt and asphalt paper used in waterproofing the foundation of the subway structure are visible in photograph 115, while in photograph 104, workers apply a coating of waterproofing to the roof of the subway structure prior to backfilling and resurfacing the street.

Photograph 30 illustrates the process of placing the waterproofing between the two layers of concrete comprising the foundation. Workmen covering the brick side walls with asphalt waterproofing are shown in photograph 120. The terra cotta ducts for electrical cables are visible at the right between the waterproofed brick and the steel columns. Photograph 116 illustrates the same process, but at a stage before the concrete foundation for the steel side columns has been poured. The steel beam and concrete structure allowed either the full or a partial width to be built, "with an absolute certainty that the several sections will fit together, connections between the rigid members being made of plastic and easily molded concrete."⁹³ The partially completed subway structure visible in photograph 101 exemplifies this method of construction.

A modification of the standard steel beam and concrete structure was used in constructing the subway beneath Lenox Avenue. The steel I-beams normally used in the side walls and roof were replaced by one-and-an-eighth to one-and-a-quarter inch thick steel rods embedded in the concrete. The rods were spaced from four to ten inches apart and surrounded by eighteen to thirty inches of concrete, depending upon the load the roof was expected to carry."⁹⁴

Standard bulb angle columns located between the tracks added support to the roof. The reinforced concrete construction used beneath Lenox Avenue is illustrated by photograph 15. Both the reinforcing rods to be imbedded in the concrete and the center row of bulb angle columns are visible. Four and a half miles, 23% of the subway, was built as a concrete lined, arch tunnel. Photograph 29 illustrates a completed section of two track, concrete lined, arch tunnel. The transition from standard steel frame to concrete arch tunnel construction is visible in illustration 121. Five miles, 24.6%, operated above ground, running upon a steel viaduct. Cast iron lined tubular tunnels carried the subway beneath the Harlem and East Rivers.⁹⁵

With the route and type of structure decided upon,

... an investigation was begun as to the topographical and geological features, the nature of the abutting buildings and their foundations, the sewerage system affected, and the presence of other surface and subsurface structures, such as elevated and surface railways, water mains, gas pipes, compressed subways for telegraph, telephone, light power and other electric wires, etc.⁹⁶

To assure adequate supervision of the sub-contractors, the fifteen sub-contract sections were organized into four engineering divisions:

Division 1, sections 1, 2, 3, and 4;
Division 2, sections 5a and b, and 6a and b;
Division 3, sections 7, 8, 9a and b, 11, 13, and 14;
Division 4, sections 10, 12, and 15.

A Sewer Division was also created to supervise the work of relocating and reconstructing the sewer and drain system.⁹⁷

The first shovel of earth was turned at City Hall Park in ceremonies held on March 24, 1900. The next day work on the 20.5 mile subway began in earnest.

The first step in constructing the subway was relocating all the sewers and storm drains intersecting the right of way of the subway. The Chief Engineer estimated that 7.2 miles of sewer along the right of way and 5.13 miles of sewer beneath other streets would be reconstructed.⁹⁸ Manhattan's sewer system was the combined type where both sanitary sewers and street storm drains connect and discharged together. The sewers ran beneath the streets and avenues where they discharged into larger, lower level mains whose final outlet is in either the North (Hudson) or East Rivers, depending upon the specific gradients and topological conditions of each local area. Since constant expansion and frequent alterations made the records of the Sewer Department cumbersome and confusing the work with, the contractor undertook a comprehensive sewer survey. The sewer division engineers sought to locate all sewer survey. The sewer division engineers sought to locate all sewer, mains, and outlets, measure every manhole for depth, determine the flow, drainage, area covered, and run-off of each locality, and wherever possible, examine the internal condition of the sewer mains along their entire length. The engineers concluded that since the path of the subway bisected Manhattan along a north-south axis the

the best solution was to accept this division and direct the flow of the sewers on the east side of the line to the East River and all sewer on the west side of the line to the North (Hudson) River, unless gradients prohibited this practice. This system resulted in the construction of sewers running parallel to the subway which then emptied into the existing low lying mains.⁹⁹

The need to construct the sewers in accordance with a multitude of specific local conditions produced a sewer system that lacked a uniform method or type of construction, varying instead as local conditions dictated. The finished sewer system used all of the standard types of sewer construction as well as few novel designs created to overcome the problems encountered at Canal Street and Chathan Square, and 110th Street and Lenox Avenue, and Railroad Avenue and 149th Street. The construction contract specified that sewers be constructed of either arched brick masonry or vitrified concrete or iron pipe, which ways was not most appropriate for each section.¹⁰⁰ The construction of a typical brick arch sewer is illustrated in photograph 87. Wooden stave (circular) and wooden box construction were permissible where conditions necessitated, primarily at the East River disposal outlet.

Concrete sewers, costing as much as one third less than the conventional brick arch sewers were also constructed. The Engineering News, described the construction of concrete sewers:

Previous to setting the invert form in place for constructing a length of invert, concrete was placed on the bottom of the trench in a layer thick enough to bring its top surface up to within from 1/2in. to 1/4in. of low-line grade. To ensure the accuracy of this work and also to ensure the accurate alinement of the form, a template was suspended from the trench timbering and adjusted to line and grade. After placing the bottom layer of concrete, the form was accurately set in position by resting its rear end on the end of the last completed invert and supporting its forward end on a foundation accurately set to grade. The flow line was then accurately formed by filling the space between the bottom of the form and the concrete foundation layer with a mortar of one part Portland cement to one part sand. The form was then firmly braced in position by struts nailed to the trench sheeting and vertical planking was set up to form the outside of the spandrel. The concrete was then placed and carefully rammed against the form so as to ensure a smooth surface. The invert concrete was composed of one part Portland cement two

parts sand and four parts of stone broken to pass a 1-in. ring. This mixture was placed (not dropped) into position and carefully rammed. The ends of each successive section of invert were mortised to ensure a firm and intimate connection with the next section, and 2 x 4-in. strips, laid longitudinally along the center of the tops of the sidewalls of the invert section formed mortise for bonding the arch ring to the invert. The forms were left in place at least 24 hours to allow the concrete to set. After the invert was set and the form withdrawn a thin cement wash was brushed over its surface to smooth any slight roughness. This work gave a surface almost polished in comparison with the best brick-work.¹⁰¹

Combinations of concrete and brick construction, where concrete inverts (bottoms) carried a roof arch of brick, were also used. Photograph 114 illustrates a finished concrete sewer invert, with the exterior of a subway wall on the right.

There were points at which the sewers had to be carried across the path of the subway or where the large size of the sewer required special construction. Canal Street, 110th Street and Lenox Avenue, and Railroad Avenue and 149th Street were the most prominent examples of special work. The Canal Street sewer, draining an area of 180 acres, had previously emptied into the Hudson River. With the construction of the subway, the Canal Street sewer had to be diverted to the East River and a new outfall line constructed. The sewer started as a five and a half foot circular brick sewer beneath Canal Street, expanded to a six and a half foot sewer beneath Chatham Square, Leonard, and Madison Streets, became a box sewer between Madison and South Streets, and was finally funneled into two circular wooden stave pipes at its outlet at the East River. With the exception of the Chatham Square section, which was built in tunnel, the Canal Street sewer was constructed in an open cut. Because of the heavy street traffic and the large number of street railway tracks, the thirty foot section beneath Chatham Square was built in tunnel. The diameter of the tunnel was only six and a half feet, but the fine sand that was penetrated and the fact that the tunnel was only thirty feet beneath the surface complicated the task.¹⁰²

At Lenox Avenue and 110th Street, a six foot six inch diameter circular brick sewer, draining 124 acres of the west side of Manhattan, was intersected by the subway. A new sewer of equal diameter, but to a depth sufficient to pass beneath the subway was constructed on either side of the subway structure. Photograph 90 illustrates the construction of this new 110th Street sewer. Where the sewer passed beneath the subway, the brick sewer illustrated in photograph 90 was replaced by three 42 inch diameter cast iron pipes.

An objective of the sewer division engineers was "to arrange for the permanent flow of sewerage without pumping."¹⁰³ Only one sewer was reconstructed below the tide line, necessitating the use of a siphon to assure proper drainage. In crossing beneath the subway at Railroad Avenue and 149th Street in Manhattan, the sewer dropped below the tide level. Two siphons were built so that should the sewer prove not to be self-cleaning, one siphon could be shut off and cleaned while the other continued to function.

During the first few months of sewer reconstruction, the engineers and contractors organized the work force, procured the equipment, and arranged for the delivery of the materials needed for the actual construction of the subway. All but one sub-contractor agreed that the economical and efficient use of pneumatic tools hoists, drills, pumps, concrete mixers, and riveters required a central air compressor power plant for each section or groups of sections. To satisfy the need for compressed air, nine central compressed air stations were constructed:¹⁰⁴

COMPRESSOR PLANT, SECTIONS 1 AND 2

BUILDING.--One Building, 52' X 65'.
BOILERS.--Two 100 H.P. boilers of Edward
Burnhorn make.
Two 120 H. P. boilers of Penn.
Iron Co. make.
AIR COMPRESSORS.--Two Ingersoll compressors,
250 H.P. each, cylinders 24"X30"

COMPRESSOR PLANT, SECTION 3

BUILDING.--One building, 36'6"X87' 6"X30'3"
BOILERS. --Five 100 H.P. boilers (tubulars).
AIR COMPRESSORS. -- Three Ingersoll compressors,
each 24"X30".

COMPRESSORS PLANT, SECTION 4 AND 5-A.

BUILDINGS. --Engine and compressor room, 63'X 30'4":
boiler room connected, 12'4"X28'3".
BOILERS.--Two 200 H.P. boilers (Water tube).
AIR COMPRESSORS.--One Rand-Corliss compressors,
class B-B-3. rated at 700 H.P.
22"X40"X48".

COMPRESSOR PLANT, SECTION 5

BUILDING.--One building, 40'X76'.
BOILERS.--Two 125 H.P. boilers (Tubular).
Two 100 "
AIR COMPRESSORS.--Two straight line piston in-
let, Class A, Ingersoll Sigles com-
pressors: each rated at 192 H.P. fur-
nishing 960 cu. ft. of free air per
minute. 22"X22"1/4 X 24". 'Also one Inger-
soll compressor, rated at 245 H.P.,
furnishing 1,225 cu. ft. of free air
per minute, 24"X24 1/4" X 30".

COMPRESSOR PLANT, SECTIONS 6-A AND 6-B

BUILDING.--Wooden building, 88'X45', located west of 76th Street on the dock lands between New York Central tracks and Hudson River.

BOILERS.--Five boilers of locomotive type.

AIR COMPRESSORS.--Three Rand Class "C" straight line compressors, steam and air cylinders 24 inches diameter by 30 inches stroke, running at 90 revolutions per minute, having a combined capacity of 1,225 cu. ft. of free air per minute, which compressed to 90 lbs. requires 750 H.P.

COMPRESSOR PLANT, SECTIONS 7 AND 8

BUILDING.--Corrugated iron building on 111th Street and St. Nicholas Avenue; size 106X30X18 ft. Additional building for storage of coal, tools, etc., size 20X71 ft.

BOILERS.--Four 125 H.P. boilers, each made by the Gem City Boiler Co., Dayton, Ohio.

AIR COMPRESSORS.--Two Ingersoll compressors each 24"X30".

COMPRESSOR PLANT, SECTION 9-B

BUILDING.--Frame building corner Gerard Avenue and East 149th Street; size 26X50X16 ft.

BOILERS.--Two boilers, 100 and 125 H.P. respectively.

AIR COMPRESSORS.--One Ingersoll compressor, 18"X24".

COMPRESSOR PLANT, SECTION 11

BUILDING.--Frame building. 22'X50'X13'.

BOILERS.--One 150 H.P. locomotive boiler.

AIR COMPRESSORS.--One Rand compressor, class "C", 24"X30".

COMPRESSOR PLANT, SECTIONS 13 AND 14

BUILDING.--Corrugated iron building, situated between 162nd and 163rd Streets, North River; size 70X40X18 ft.

BOILERS.--Two 125 H.P. boilers, each made by the Gem City Boiler Co., Dayton, Ohio.

Two 125 H.P. boilers, each made by the Erie Boiler Co.,

One 170 H.P. N. Y. Central R. R. loco. boiler.

AIR COMPRESSORS. --Three compressors, Rand Drill Co., steam Cylinders, 24" diam. 30" stroke, air cylinders 24" diam. 30" stroke. air capacity 1, 335 cu. feet, at 85 revolutions per minute.

The heavy volume of street traffic, the presence of large buildings with footings resting on sand close to an above the bottom of the subway excavation, and the complicated design of the City Hall station and turning loop, made section 1 especially costly, difficult, and tedious to construct. The original plans for section one called for the four track line to continue south past the Brooklyn Bridge station and form a two track turning loop around the United States Post Office building. The decision in 1900 to extend the line down the east side and into Brooklyn brought about an alternation in this design. The revised plans called for the two interior or express tracks of the main line to continue to Brooklyn while the two exterior or local tracks dropped below the main line, veered west a short distance, and formed a single track turning loop beneath City Hall Park.¹⁰⁵

The loop under City Hall Park was the first part of section 1 to be excavated. The loop, unlike the steel frame portions of the subway passing beneath Park Row, was a concrete arch structure with a width of 11 feet and a height of 14 feet, 10 inches. The excavation was open cut work except for that portion of the loop passing under the vaults of the Post Office Building and the ten story New York Times Building. Tunnels were driven beneath these two structures. The entire excavation for the loop, as was all of sections 1 and 2, was in soft, loamy sand, which was removed by hand shoveling.

In excavating sections 1 and 2, the methods varied depending upon the volume or surface traffic and the extent to which a particular street could be closed to traffic.¹⁰⁶ The heavy volume of street railway traffic on Park Row prohibited its being closed. It was necessary to dig four narrow trenches parallel with the street, one on each side of the street railway line and one each outside the line where the exterior wall of the subway structure would be built. When the trenches were six or seven feet beneath the street railway track, horizontal tunnels, perpendicular to the line of the railway and the trenches were dug and the street surface supported by short timbers. Through these transverse tunnels, spaced at ten-foot intervals and between the locations where the actual subway columns and girders would be erected, 14 by 14 inch timbers or "needle beams" were placed. These needle beams were wedged up against the roof of the tunnel and held firm by temporary timber supports. Beneath these transverse beams a half-dozen six by six foot shafts were then dug to a depth below the projected foundation grade of the subway structure. Timber columns, twelve inches square, were set in these shafts and wedged tight against the transverse needle beams. After the columns were in place and carrying the weight of the beams and the street above them, the remaining earth could be carefully removed and the trench excavated to the full depth and width required by the subway structure. Construction could then proceed while

traffic on the street, above continued to flow uninterrupted by Photograph 105 illustrated a street where subway construction is proceeding beneath the surface while traffic moves without a major interruption.

Along Elm Street light traffic and the lack of asphalt paving permitted the contractor to close the street and excavate the full width of the subway without concern for maintaining a roadway above the excavation. Construction of the subway in open excavation along Elm Street is shown in photographs 99 and 100. Photograph 107 is another view of construction in the downtown area where the full width of the street was excavated.

Section 1 and 2, were excavated entirely in sand. In section 3, rock at a level interfering with the subway structure, necessitated different methods of construction. The rock, first encountered at 10th street, gradually rose closer to the surface until it was within three feet of the street and "directly beneath the yokes of the electric railway..." at 15th Street.¹⁰⁷ The excavation of the remaining portion of section 3 was through rock of varying depths. To minimize the disruption of traffic, the initial cut and cover construction in section 3 was limited to one half of the street. However, "as the work progressed it was found that the inconvenience resulting from the excavation on one side of the street was felt with almost equal force upon the other, and that the building of the railway half at a time produced almost as much interference with street traffic as would the building of two railways."¹⁰⁸ Excavation of the full width of the street was subsequently permitted. Temporary steel and wooden bridges allowed the orderly, if restricted, flow of streetcar and vehicular traffic above the excavation.

The streetcar tracks were carried on temporary trestles while excavation and construction progressed below. In building these temporary trestles, trenches were dug at intervals of forty feet transverse to and beneath the streetcar tracks. Upon reaching the depth of the subgrade of the subway, concrete footings were poured in the trench and a timber trestle or bent erected. Along the outside and between the middle of the streetcar tracks, 24 inch steel beams, forty feet in length were laid longitudinally in a trench dug just below the bottom of the tracks. The beams rested upon the tops of the previously constructed timber trestles. Transverse to the street tracks, trenches dug so that cross beams could be inserted beneath the tracks and fastened to the longitudinal I-beams by rods and bolts. Once a sufficient number of transverse cross beams had been placed to carry the weight of the tracks and securely tightened, the excavation of all the remaining earth and rock could begin. This system of carrying the streetcar tracks permitted the total excavation of the street. The construction of the subway could proceed with only one interruption every forty feet. After the subway structure was completed, brick piers built on the roof of the structure carried the weight of the streetcar tracks while the trestles were removed, the excavation backfilled, and the pavement restored.¹⁰⁹

Overhead cableways were used extensively in sections 1, 2, and 3 to remove the excavated material or "spoil". Derricks were placed where large masses of rock and earth were to be removed. The derricks hoisted the steel buckets full of spoil out of the trenches and to the surface. Once on the surface the buckets could be attached to the cableway, elevated from the ground, and moved along the length of the system to the end of the excavation, where the spoil was dumped into horse drawn carts for removal to any of several disposal sites.¹¹⁰ Photograph 108 illustrates the manual loading of the excavation buckets prior to being attached to the overhead cableway. An overhead cableway and a bucket of spoil about to be dumped are seen in photograph 106.

In the area of Union Square, the entire mass below the level of the streetcar tracks was solid rock. Photographs 31, 110, and 19 illustrate the construction of the subway at Union Square in section 3. The presence of rock for the entire depth of the excavation is clearly visible in these photographs. A pedestrian bridge over the excavation, a stiff leg derrick for removing rubble from the excavation, and a multitude of air compressor lines are visible in photograph 112, also taken at Union Square. A close view of a tripod-mounted, compressed-air rock drill is seen in photograph 113.¹¹¹

To avoid damaging the streetcar tracks when using dynamite to excavate for the subway, the tracks of the streetcar line were removed to the east side of 4th Avenue. After the relocation of the streetcar tracks, sufficient space was available to excavate and construct the two southbound tracks of the subway. The completion of the southbound side of the subway permitted the relocation of the streetcar tracks to their original position, and the construction of the remaining two, northbound, tracks of the subway. Photograph 32 and 33 are two views of the construction at Union Square taken one year apart. The space occupied by the streetcar tracks in photograph 32 is the location of the southbound tracks of the new subway in photograph 33, the streetcar tracks having been relocating east of the Avenue.

Section 4 presented the engineers and contractors with the most vexing problems. This section passes beneath a rocky elevation known as Murray Hill. In 1900, this neighborhood contained some of the most prestigious residences in Manhattan. Geologically, Murray Hill is a surface formation of mica schist rock whose strata lie at an angle of 45°. This formation is subject to slides when sufficiently disturbed, and two such slides occurred during construction. The contract for section 4 called for the subway to be entirely in tunnel from 34th Street to 41st Street. Complicating the construction was the presence of a two track tunnel used by the Metropolitan Street Railways. This tunnel under Park Avenue necessitated separating the four tracks of the subway and arranging them into two double track tunnels. The two pair of tracks were located beneath and at the sides of the Metropolitan Railway tunnel.

The first step in constructing the tunnels was to sink four shafts, one at each end of the tunnels. The shafts were located on the side of the street car tracks at each end of the tunnel. A strong timber platform was built over the street, connecting the two shafts. This timber platform carried the equipment needed to operate the compressed air drills used in driving the tunnel.

The two shafts at the south end of the tunnel were the first to be sunk. Work began on the east tunnel shaft on September 17, 1900 and on the west shaft on October 15, 1900. These two shafts were thirty feet long, twenty feet wide, and directly over the route of the tunnel. The south shafts penetrated a solid strata or rock that required no timbering. Using air drills and dynamite to break the rock loose, and stiff leg derricks to excavate the spoil, work progressed without incident. The final depth of the two shafts, 24 feet, was reached within four months. The two north shafts required timbering as they hit both rock and layers of hard earth. Although smaller than the south shafts they were sunk to a deeper depth, 38 feet.

On December 11, 1901 the driving of the west tunnel began from the south shaft. This tunnel was driven using the "top heading" method. Figure 1 indicates the sequence used in driving the tunnel by method. In driving the east tunnel northward a "bottom drift" was employed. The rapidity with which the east tunnel was driven northward using the bottom drift, prompted the contractor to discontinue using the top heading in the west tunnel and proceed with a bottom drift there as well. Figure II indicates the sequence of the excavation using the bottom drift. After the initial excavation (portion 1) the tunnel was widened by removing rock on both sides, (portion 2). The removal of portion 3 followed, and lastly, the upper portion, number 4 was removed. Because of the very soft and decomposed rock encountered in driving the east and west tunnels south from 41st Street, the top heading was initially used on both. Here permanent timbering was also necessary. Improvement in the rock in the west tunnel permitted the contractor to substitute the bottom heading (Figure 2), while maintaining the top heading in the east tunnel.

The method of driving the Murray Hill tunnels differed from the conventional practice of American rock tunneling, which, with few exceptions, were driven using the center top heading pattern. The Murray Hill tunnels used the bottom drift method, wherever possible because, according to Chief Engineer, Parsons, it was more economical and permitted more rapid excavation.¹¹²

In driving the tunnels, compressed air drills bored holes about seven feet deep with a diameter starting at 2 and 3/4 inches and tapering down to 1 and 3/4 inches. These holes were filled with small charges of dynamite and blasted. Throughout the driving of the Murray Hill tunnels, dynamite blasting presented major problems. The windows of buildings adjacent to 34th Street suffered considerable damage, window prompted the contractor to cover the shafts of the tunnels with heavy timbers. Deflecting the air flow in this manner considerably reduced the problem. Deeper holes were also bored so that rock

itself would bear the burden of the explosive shock and reduce the vibrations experienced at the mouth of the shaft. 113

While the driving of the tunnel differed at each end, the method of removing the excavated materials was similar at both ends. Three parallel narrow gauge tracks were laid on the floor of the tunnel and advanced to the face of the tunnel excavation. Small flat cars upon which steel boxes (skips) were placed, carried the excavated material between the face of the tunnel excavation and the shaft, where the surface derricks lifted the skips to the street. The material from the bottom portions of the tunnel was loaded into the excavation by hand. In removing the material from the upper portions of the tunnel, a "traveler" or rolling platform was used. Mounted upon this wooden platform were air drills and temporary roof support columns. The platform was moved back when blasting thus allowing the rock to fall upon the tunnel floor where it could be loaded into the excavation cars.

Lining the two tunnels with concrete presented an entirely new set of problems. The first problem was to establish an adequate concrete mixing facility. Stone crushing machinery was elevated above the street on heavy wooden platforms, and the concrete mixing machinery was placed within the vertical tunnel shaft. The stone removed from the tunnel was hoisted to the surface, transferred to cars, and pushed to the crushing machine on tracks laid upon the elevated platform. Once crushed, the stone was sent to the mixing machinery located within the shaft. The stone, sand, and cement were dumped down the shaft and funneled into a rotating mixer held aloft by a wooden framework. The mixed concrete could be discharged directly into the steel skips and and pushed along the tunnel to wherever it was needed.

The footings for the tunnel sidewalls were poured first. These footings extended approximately 18 inches into the tunnel from the sidewalls. Rails were laid upon this concrete base to carry a rolling platform or traveler". Three travelers were used: one to build the sidewalls, one to carry a derrick, and a third for forming the roof arch. The first wooden platform carried the wooden lagging or forms which shaped the sidewalls. This platform was rolled to where the sidewalls were to be constructed. The forms were placed, and the traveler secured against movement. Concrete was then shoveled between the rock and the form and the sidewalls were constructed. After the concrete hardened the form was moved forward, and the next section of sidewall was poured. After the sidewalls were constructed the derrick and the roof arch traveler advanced. The derrick moved between the sidewall and roof arch platforms lifting the concrete into a position where workers could shovel it into the forms.

The roof arch traveler provided the forms for lining all of the tunnel above the previously constructed sidewalls. The roof arch forms placed, concrete was shoveled through the top of the form until the concrete on both sides reached the crown of the arch. Starting at the rear and working forward, the concrete was shoveled and rammed into the crown of the arch until the entire area behind the form was filled.

Accidents plagued section 4. On January 27, 1902, the first of a number of fatal accidents occurred. A large but undetermined quantity of dynamite, stored at the north end of the section (41st Street) exploded. Five persons were killed and a number of buildings extensively damaged by this explosion.¹¹⁴

Less than two months after the explosion on 41st Street, a severe rock slide occurred between 37th Street and 38th Street beneath Park Avenue in the east tunnel. The Engineering News reported the event:

During the night of March 19, about 65 feet in length of the east wall and the east part of the roof slid down into the drift partly filling it. An examination of the slide showed that a wedge shaped stratum broadest at the bottom had slipped down between the adjoining strata. The slip did not reach to the street surface, that is the fallen rock had broken away from the rock above, leaving a cavity.

Immediately after this first disturbance of the rock the subcontractor concentrated his workforce and began shoring the undisturbed roof of the drift. This work was continued during the following day, March 20.

Despite this shoring a wedge shaped crack parallel to the drift and near the west edge of its roof began to open. This crack extended up into the rock at an inclination of 45°, and constantly increased until the morning of March 21, when the east half of the roof of the drift fell in crushing the supporting timbers. The slide extended to walls of the adjoining houses, causing them to fall in part. Steps were taken at once to shore up the house walls and prevent further falls of rock by discontinuing work and by all other means which suggested themselves. The total length of the tunnel affected by the rock slide was about 65 feet.¹¹⁵

The accident alarmed adjoining property owners and focused public attention of the hazards of subway construction. A vigorous campaign waged by property owners followed resulting in the Board's appointing a committee of engineers to investigate the cause of the accident and recommend action to insure against recurrence.

The investigating committee consisted of five civil engineers, two appointed by property owners one by Board of Rapid Transit Commissioners, one by the Chief Engineer of the Commission, and William Parsons as Chief Engineer. The report of the engineers concluded that work could continue in the east and west tunnels provided their precautions were followed.¹¹⁶

Work was resumed in accordance with the recommendations of the engineering committee and safely pursued until June 17, 1902, when the final fatal accident on section 4 occurred. During an inspection tour accompanied by Chief Engineer Parsons, Ira A. Shaler, the sub-contractor of the section, was severely injured. Parsons' diary describes the accident.

With Rice, started with Shaler at 34th Street and went through the east tunnel. Examined the work and then examined the rock at the north end of the roof at 40th Street. Told Shaler I did not like the looks of it and he replied that it was perfectly safe, when all at once some rock fell, injuring him.¹¹⁷

Two weeks later, Ira Shaler died.

The second engineering division included 4 sub-contract sections, numbers 5a and b, and 6a and b. Section 5 began at the center line of 41st Street and Park Avenue, extended north to 42nd Street, and curved west beneath 42nd Street. This section continued west under 42nd Street until it intersected with Broadway. At Broadway, the line turned north and continued up along Broadway to 47th Street. The center line of 47th Street marked the end of section 5a. Work on section 5a began on February 25, 1901. The start of work on this section was delayed by negotiations between the New York Central and Hudson River Railroad Company and the Board concerning a possible joint station at 42nd Street. When months of negotiation with the New York Central produced no agreement, work proceeded according to the original plans.¹¹⁸

The terrain in section 5a consisted of a five to fifteen foot layer of densely packed earth over solid rock. The major problem in section 5a was the multitude of large sub-surface obstacles 48 inch water pipes, sewer mains, and electrical conduits and the electric railway tracks running along, and intersecting with, 42nd Street. Two tracks ran along 42nd Street, while lines crossed it at Park, Sixth, and Broadway. Large buildings on both sides of the subway right of way also posed problems. A number of buildings along 42nd Street maintained underground vaults extending as far as eighteen feet into the projected path of the subway, as did the foundations of the elevated railway station at 42nd Street and Sixth Avenue.

While the presence of so many varied surface structures made construction in section 5a difficult, the subway structure itself was not unusual. With the exception of a small portion at the eastern end of the section, where it emerged from the Park Avenue tunnel and curved west beneath 42nd Street, section 5a was the standard four-track, steel-bent structure. Differing excavation techniques were used, depending upon the specific surface and sub-surface impediments encountered. The property under which the subway zig-zagged from Park Avenue and curved west below 42nd street was privately owned. This property was condemned, and the subway was built in an open cut. The section of subway between Park Avenue and Fifth Avenue included a station and a fifth track built for switching operations. Consequently, this section of the line was wider than most other portions of the standard four track line.

The depth of the excavation between Fifth and Sixth Avenues varied from 25 to 35 feet below the surface of the street. Generally between ten and twenty-seven feet of the excavation penetrated solid rock. In excavating this portion of section 5a, a 15-foot wide trench was dug longitudinally along the south side of 42nd Street. This trench was sheeted and braced in the usual manner. Photograph 103 illustrates construction in a trench on 42nd Street between 5th and 6th Avenues, in which steelwork for a single track was erected. At frequent intervals, however, roof arches were left unturned so that the rubble from subsequent lateral excavations might be removed. Once this single track was completed, transverse drifts north below 42nd Street were begun. These lateral excavations were at the level of the subway roof and driven north approximately 20 feet, to a point where the third row of steel columns would be erected. After this drift was sheeted, 24 inch steel beams were inserted into the drift, one end lying on the roof of the subway and the other resting on the rock within the drift. These "needle beams" shown in photograph 11. With the underpinning securely in place, the space to be occupied by the subway structure was excavated, the structural steel erected, and the roof arches formed. Photograph 98 illustrates the construction of the brick arches between the roof beams of the subway. The relation of the completed subway structure and Columbus monument is most clearly defined in drawing 193.

Section 6a and 6 were awarded to sub-contractor William Bradley. The material excavated along this portion of the line consisted of a layer of earth and rubble covering rock. Section 6a and b differed considerably from the four track line constructed in sections one through five. The standard steel-frame, four-track structure was carried north in section 6 as far as 96th Street. Ninety feet north of 69th Street the interior, or express, tracks descended and the exterior or local, tracks ascended. Between 103rd and 104th Streets the express tracks swung east, passing beneath the uptown local track. The two exterior tracks, separated at 96th Street, continued north beneath Broadway. At 100th Street a third track was added to the

two already coming up Broadway. This third track carried blocking which supported the street surface. Once these were in place and the street was sufficiently supported, the contractor excavated the rock and erected the columns and roof beams for another track. He repeated this procedure until the steel frame and roof for all four tracks was completed.

Naughton and Company constructed section 5b, from the center of 47th Street north beneath Broadway as far as 60th Street. Work began on September 20, 1900, mostly through rock with a shallow cover of earth, and with the additional problems of a double track electric street railway line running along the middle of Broadway, and a multitude of sub-surface pipes and sewers. The contractors first excavated the space between the curb and the streetcar line. Lateral excavations beneath the tracks, supported by wooden posts, permitted the construction of onehalf of the subway structure. After the pavement was restored over the completed half of the subway, the same method was used to construct the other half.

What made the work of section 5a unusual was the necessity of constructing the line beneath the 724 ton, 75 foot high monument to Christopher Columbus located at Broadway and 59th Street.¹¹⁹ The Columbus monument is a large granite statue carried upon a 50 foot high shaft. The shaft is mounted on a three-tiered pedestal. The foundation is a 45 foot square, 14 inch deep pad of concrete and brick masonry. The first step in building the subway, under the monument was to sink two shafts, one each on the north and south sides of the monument's foundation. These two shafts were carried to a depth three feet below the foundation line of the subway construction. A tunnel 6 feet wide and 7 feet high was driven from these two shafts out beneath the foundation of the monument. Upon the tunnel floor concrete was laid and 12 by 12 wooden columns were placed between the concrete floor and the foundation of the monument. With this temporary wooden underpinning in place, workmen built a solid masonry foundation. A large steel girder, resting on two wooden trestles, was then placed beneath the eastern edge and wedged tight against the monument's foundation. This girder is continued as far as 135th Street where a large storage yard was located. The two tracks veering east at 103rd Street formed the east side line into the Bronx.

In both 6a and 6b, open excavation was the predominant method of construction. The street railway tracks were supported on wooden truss bridges, as in section three. Photograph 117 illustrates the different methods by which Broadway streetcar tracks over section 5 and 6 were supported. In the foreground, section 5, the tracks are supported by wooden posts under the left side of the track, barely visible at the center of the photograph. The truss bridge seen in the upper left side of the photograph marks the start of section 6, and is typical of the structures used in support the street railroad.¹²⁰

The east side line and engineering division 3 began with section 7, which curved east from Broadway under private property from 103rd Street and Central Park to Lenox Avenue and 110th Street. Section 7 was a double track tunnel through rock, except for a short portion of open cut. The contractor easily tunnelled section 7, as the rock was solid mica schist, bearing little water. The contractor drove the tunnel using two shafts and one portal. The use of a portal was made possible by the abrupt sloping of a rock ridge into a deep ravine in Central Park. Mules pulled small railroad cars loaded with rubble to the shafts, where a heavy elevator hoisted the rock-laden cars to the surface. Work progressed rapidly because of two 8-hour shifts on the headings served by the shafts and one 8-hour shift on the portal heading.

Photographs 5 and 6 illustrate tunneling in section 7. Photograph 5 shows the traveler used in driving the top heading. Fallen rock and rubble was loaded by hand into the mule drawn cars, pulled beneath the traveler to the shaft head, and removed to the surface. Photograph 4 5 illustrated the forms used in lining the roof arch. Completed concrete sidewalls are visible at both sides of the photograph. Approximately 100 feet of section 7 was built using open cut methods. Once the cut was excavated, a two track concrete arch was formed.¹²¹

Section 8 extended from 110th Street to 135th Street under Lenox Avenue. Two contractors, Farrell, Hopper and Company and John C. Rodgers, built this section. Farrell, Hopper constructed the portion between 110th Street and 116th Street, sub-letting the portion between 116th Street and 135th Street to Rodgers. In section 8, the subway travelled in a two track, flat roof, reinforced concrete structure. The structure was located on the west side of Lenox Avenue, between the west curb and the street railway tracks that occupied the center of the Avenue. Four stations were located within this section.

Section 8, built through sand and sand mixed with gravel, offered few serious difficulties. Much of the sand was of a high enough quality to be screened, washed, and used for mixing with concrete and mortar. Because of the width of Lenox Avenue, the relatively low level of development along this portion of the line, and the nature of the excavated material, no unique methods of construction were employed. The standard procedure was to sink a single trench to the foundation grade of the structure, brace and sheet the sidewalls, lay the concrete foundation, erect the steel, and concrete the roof all within this single trench.¹²²

The only thing worthy of note in section 8 was the reliance upon mechanical devices different from those used for other sections. The location of the subway on one side of the Avenue, and the absence of street railway tracks above the excavation, made for an easy job. Bridges were required at the intersection of cross streets, but these

were of routine construction. The contractor could use a locomotive crane to handle the excavated material. This steam powered crane travelled on tracks laid on the street parallel to the excavation. The crane was used for removing the loaded skips and dumping them directly into horse drawn wagons. Along Rodgers portion of section 8, overhead cableways of varied description were used to remove the material from the trench. 123

As his job was the simplest, Rodgers completed it quickly, finishing a two and a half block long section of two track subway and resurfacing the Avenue in 90 days. And even with delays in steel delivery, he completed a one-block section of subway in 36 days. 124

Steep grades and cast iron tubes distinguished section 9 from the remainder of the Contract One rapid transit subway. The 8,000 feet of section 9 began at 135th Street and Lenox Avenue in Manhattan, ran under the Harlem River, and surfaced in the Bronx at Melrose Avenue. In the portions of this double track section not beneath the river, three types of construction, standard steel frame, reinforced concrete, and concrete arch, were used. Open excavation was permitted for the entire length of section 9 except, of course, for the Harlem River tunnel. Photograph 123 illustrates the open excavation and construction of a concrete arch structure at Mott Avenue and 149th Street in the Bronx.

In tunneling the Harlem River, twin cast iron tubes were constructed. The two tubes were each 450 feet long with an interior diameter of fourteen feet, and were connected by a vertical cast iron diaphragm. The interior of one of the tubes is seen in photograph 135. The wall at the right of the photograph was the diaphragm linking the two tubes. The two tubes were surrounded by a layer of concrete with a minimum thickness of one foot. The roof of the tubes was covered by a layer of concrete two and one half feet thick. An order issued by the United States War Department required that the top of the subway tunnel be at least twenty feet below the tide level of the river. 125 The grades approaching the Harlem River tunnel were a full three per cent, the steepest anywhere along the Contract One right of way. 126

An examination of the riverbed indicated the presence of a layer of clay of varying thickness lying above fine silt. The rock beneath the clay and silt dropped sharply at the west bank. The presence of clay, silt, and irregular rock assured the contractor of difficulty and danger should he proceed to drive the tunnel with a conventional shield. He suggested building a rectangular-shaped, submerged coffer dam extending from the shore to the middle of the river and within this caisson-like structure, excavating the rock and earth and constructing the tunnel, one half at a time. The Chief Engineer of the Rapid Transit Commission agreed to permit this unique method of tunnel construction, and work on the Harlem River tunnel began from the west side of the river in June, 1901.

The first step was dredging a channel across the bottom of the river following the projected line of the tunnel. On both sides of this channel, working platforms, carried on piles, were constructed to house compressed air equipment and derricks. Contractor McBean described the remainder of the construction:

In this channel foundation piles and a row of specially prepared heavy timber sheeting, along each side and across the ends, were driven and cut-off to a true plane about 25 feet below the surface of the water. This sheeting forms the sides and ends of a pneumatic working chamber. For the roof of this chamber a platform of timber, 40 inches in thickness and extending the full width and length of the tunnel section, was built and sunk and rested on the cut-off sheeting, which formed the sides and ends as above described. Simultaneously with pumping the water from under this roof compressed air was forced into the chamber under pressure corresponding to the pressure of the water above the roof. Inside this chamber the west half of the tunnel was built and then the timber roof was removed.¹²⁷

While constructing the easterly portions of the tunnel, a number of modifications made the construction "simpler, safer, more expeditious and less costly."¹²⁸ The sides of the east side compressed air caisson were prepared identically with those of the west side. However, the sheeting and pilings on the east chamber were cut twelve feet lower than those of the west side caisson. Contractor McBean explained the rationale for this change:

The top half of the tunnel will be built at the surface on pontoons, then launched and floated over the tunnel site and sunk into its final and true position the outward flanges of it resting on the cut-off sheeting above described; then the top half of the tunnel will be used to form the roof of the pneumatic working chamber. In this chamber the foundation and bottom half of tunnel will be constructed, with the use of compressed air, thus dispensing with the timber roof as used in the first method and greatly decreasing the cost of the construction of the tunnel in many ways.¹²⁹

Photograph 10 and 134 illustrate the above-water construction of a section of the eastern half of the tunnel prior to its being floated over the submerged platform and sunk. In photograph 10 the cast iron rings are being bolted together to form the actual tubes, while photograph 134 illustrates the same section of tube with a protective layer of concrete applied to it. Once the sections had been joined together beneath the water, a concrete lining was applied to the interior of the tunnel to protect the cast iron rings. Heavy duty water pumps were installed to prevent any possibility of flooding. (One of the Cameron water pumps appears in photograph 138).

Section 11 began at the center of 104th Street and continued north along Broadway to 125th Street. The original specifications for section 11 called for the line to be a standard steel, double track structure from the beginning of the section at 104th Street to 116th Street. Between 116th Street and 121st Street the structure was to be built as a concrete arch, double track tunnel. North of 121st Street the two tracks were to be partially built in an open cut, and as the terrain drops considerably, the northern portion between 122nd and 125th Streets was to be built between retaining walls on a masonry embankment. All work in section 11 was to be conducted in an open excavation. The workmen pictured in photograph 109 spread concrete for the foundation of the subway.

With a terminal to be located between 135th and 145th Streets, the contractor suggested constructing a third track connecting the terminal area with the four tracks at 96th Street. The Board acknowledged the utility of having a third track for express trains geared for the direction of traffic, and authorized the construction of a third track between 135th Street and the junction of the east and west side lines, just south of 104th Street.¹³⁰ The alteration of section 11 from a two track to a three track tunnel necessitated the demolition of a short piece of two track concrete arch already in place. While only 215 feet in length, the two track arch was "so strong... blasting had to be resorted to." The two track arch was replaced by a three track concrete, "polycentric roof arch" with an interior width of 37.5 feet.¹³¹ Photograph 118 illustrates a section of the three track concrete arch built at 118th Street.

Section 13 began at 133rd Street and terminated at 181st Street, while section 14 began at this latter location and terminated at Hill-side Avenue. The original sub-contractor abandoned the work prior to its completion and both sections were completed by McDonald. The unique feature of section 13 and 14 was that almost two and a half miles of the three and a quarter miles was built as a deep rock tunnel. In 1900, only the Hoosac tunnel in western Massachusetts possessed a longer unbroken rock roof than the deep tunnel driven through section 13 and 14.¹³²

The short distance between 133rd and 134th Streets was part of the north side approach of the Manhattan Valley viaduct. This structure was an earthen fill between brick and granite retaining walls. The distance between the track and the street was greatest at 133rd Street and diminished in height as the street surface rose toward 134th Street. At 134th Street, the surface of the rails and the street was almost level. The street surface continued to rise and the subway gradually descended from this point so that at 135th Street the tracks were again beneath the street. Photograph 129 illustrates the transition of the subway from an above-ground to a below-ground right of way between 134th Street and 135th Street.

Near 135th Street the subway lay close to the surface and traveled through the standard steel frame structure. Here the structure was built by open excavation through loam and sand with a small layer of rock at the lower depths. Excavation for the subway in this area is seen in photograph 88 and 13. In photograph 88 the excavation has been carried to the level where the concrete foundation will be laid. In photograph 13, the first of the steel bents used in the flat roof portions of section 13 are seen being lowered into the open excavation at 135th Street.

Between 135th and 145th Streets there are three operating tracks to the subway and five parallel storage tracks, giving the line a width of eight tracks at this point. This steel frame portion was also constructed by open excavation. Because the width of the eight track yard necessitated using the entire area beneath Broadway, this section was built one-half or four tracks at a time.¹³³

Photograph 122 illustrates the almost completed construction of one-half of the subway at Broadway and 140th Street. With the roof arches in place, backfill, broken rock from other sections of the excavation, was placed upon the structure with the use of an overhead cableway. After the backfilling was completed and the street resurfaced construction of the other half of the structure began. North of 145th Street the line was double track traveling through a concrete arch structure built in an open excavation. Photograph 94 illustrates the two track concrete arch in an open excavation on this part of the line.

Beginning at 150th Street, the street surface rose abruptly until it peaked at 153rd Street and then descended rapidly again as it heads toward 157th Street. North of 157th Street there was another abrupt rise and the street surface remained high above the level of the subway until it dropped sharply at 191st Street and Fort George, and the subway, emerging from its rock tunnel, proceeded north on a viaduct. Photograph 17 illustrates the sloping terrain necessitating the viaduct structure. A small section of track, 1,112 feet in length was constructed in tunnel between 151st and 155th Streets. Another small portion between 155th and 158th Streets was built in an open excavation. This short portion was steel frame construction and included the 157th

Street station.¹³⁴ Photograph 132 illustrates the construction of the 157th Street station and the extremely shallow space between the roof of the subway and the surface of the street.

The major tunneling project was the over two-mile-long section between 158th Street and Fort George. The tunnel was driven from portals at either end and from two shafts, one each at 168th and 181st Streets. The Fort George portal is seen in photograph 7. Photograph 97 looks south from the 158th Street portal, illustrating the change from the rock tunnel construction to the cut and cover construction. Photograph 8, 89, and 9 illustrate the same location, Broadway and 157th Street, at three stages of construction. In photograph 8, workmen are removing the pavement prior to beginning the excavation for the subway. Photograph 89 reveals that six months later the excavation had reached a depth where the driving of the tunnel could begin from the now exposed portal at 158th Street, (center of picture). In photograph 9, taken three years after the initial removal of the street pavement, the excavation has been completed, the concrete arch over the 158th Street portal has been formed and backfilled, and the concrete foundations have been poured for the 157th Street station's steel framework.

This distance between the street and the subway at 168th and 181st Streets necessitated the use of elevators. The two shafts sunk here for driving the tunnel were designed to house these elevators and to serve as a part of the station. Because they were to be used after the completion of the tunnel excavation, the location and dimension of the two shafts was determined in accordance with the needs of both construction and subsequent operation. The two shafts were located sixty feet east of the center line of the tunnel. Photograph 137 shows a form for carrying the brick arch ceiling of the 168th Street station, and illustrates the large diameter of the tunnel in the vicinity of the shaft.

Top heading, the traditional method employed in driving tunnels in the United States, was, used exclusively.¹³⁶ Compressed air powered the drills used to bore the holes in which dynamite charges were placed. Forty holes were bored for each short section of tunnel fully excavated. Diagram 189 indicates the sequence of blasting and the amount of dynamite used. The rock for this section was generally solid mica schist. However, a few short stretches, (less than 500 feet) of soft rock were encountered. At 155th, 158th and Fort George, soft rock required permanent timbering between the rock and the concrete lining.

Blasted rock was hand loaded into buckets, and carried on 36-inch gauge railroad cars. The cars were pulled by mules to the shaft and hoisted to the street. Photograph 91 illustrates the 181st Street shaft. Visible are buckets loaded with spoil to be hoisted to the surface and a multitude of pipes for delivering compressed air to the rock drills. The tunnel was completely lined with concrete. Traveling sidewall and roof arch forms, similar to those used in section 4, were used in both sections 13 and 14. Although the concrete for section

13 and 14 was all machine mixed, workers shoveled it by hand into the sidewall and roof arch forms.¹³⁷

As with section 11, the addition of a third track necessitated reconstructing a portion of the completed two track structure. In section 13, however, the steel frame structure and concrete retaining walls between 134th and 135th Streets were not demolished, but widened to accommodate three tracks. Photograph 16 illustrates the relocation of an exterior wall to accommodate an additional track.¹³⁸ Separated from the remainder of the steel frame structure, heavy screw type jacks pushed the wall to its new location. Once the wall had been moved, an additional row of longitudinal bulb angle columns and roof beam spanning the additional track were erected. In photograph 12, the ground below and behind the 200-ton concrete retaining wall has been removed and the entire wall is about to be pushed backwards on rollers to accommodate the third track.

Engineering division four consisted of three widely separated sections, number 10, 12, and 15, whose common denominator was their steel viaduct construction.

Section 12 begins at 125th Street and Broadway and continues north as far as 133rd Street. Section 12 contain the IRT's most visually impressive steel structures, the 168 foot steel arch spanning the broad depression known as Manhattan Valley, (see photograph 227). Three structures comprised the Manhattan Valley viaduct, the masonry approaches, the steel frame viaduct, and the center steel arch span. The subway approached the Manhattan Valley viaduct from both the north and the south on embankments formed by brick and granite retaining walls, (see photograph 226).

As the slope toward Manhattan Street increased, steel viaducts assumed support of the track. This portion of the viaduct consists of double bent steel towers spanned by plate girders. Over Manhattan Street, the road was carried by "a three ribbed parabolic braced arch of 168.5 feet span flanked at each end by a double bent viaduct."¹³⁹ Photograph 227 illustrates the arch portion of the viaduct. The truss bracing of the arch ribs created fourteen panels of equal length and from each panel point a column rose to carry the floor system upon which the track and station were built. Photograph 128 is a northern view of the finished structure taken from the track level. The foundations for the viaduct were concrete capped with granite. The foundations for the arch itself were three parallel piers of concrete. These arch foundations were carried to a depth of thirty feet below the street surface.¹⁴⁰

Over

Since steel delivery was delayed, the contractors had to resort to an unusual method of erection. Instead of erecting the plate girder spans at both ends and then proceeding toward the middle of the structure, the contractor began at the north end of the structure erecting one span of the viaduct from the ground. Upon this single span, an erecting traveler was built and the succeeding spans set up in the traditional manner. Once the northern portion of the viaduct was completed and the steel for the southern portion delivered, the traveler was disassembled, moved to 125th Street, and the construction procedure was repeated from the southern end of the viaduct moving north. After all the viaduct spans were standing, construction of the arch began. Each arch was shipped in four sections. Two sections, one half of the arch span, were connected on the ground. With the traveler at the southern end and derricks on the north side, the two halves of the arch were lifted into place and riveted together at the center. In photograph 18, the arch has been erected and the steel decking upon which the tracks will rest is being riveted in place.

On the west side, section 15 carried the subway on a steel viaduct north from Fort George, across the Harlem River ship canal, and into the Bronx. The standard viaduct had steel columns carrying steel plate cross girders, (transverse to the street) and longitudinal plate girder spans. Parsons provided additional details: "This structure is...supported by two rows of columns spaced 29 feet apart, so as to clear by a good margin the cars of the surface electric railway. The span between the columns varies from 40 feet to 87 feet, but is usually about 50 feet.... The structure has been designed to carry as a live load motor cars with a length of 46 feet, and weighing 100,000 lbs." To assure that the viaduct possessed "Great stiffness and rigidity," the specifications required cross bracing, and knee bracing, "between the columns and cross girders and between the columns and outside longitudinal girders." 142

In crossing the Harlem River ship canal, the engineers recommended replacing an existing highway bridge with one that would accommodate the highway, the two-track subway, and a two-track street railway line. 143

Section 10 was the northern most portion of the east side route. The entire length of section 10 was above ground, carried on a steel viaduct located over public streets (see diagram 177). The same combination of contractors responsible for constructing the Manhattan Valley viaduct and section 15, E. P. Roberts, and Terry and Tench Company, handled the foundation construction and steel erection of the section 10 viaduct. 144 Photograph 130 illustrates the erection of the plate girders of the viaduct at Southern Boulevard and Westchester Avenue in section 10.

In the Report of the Board of Rapid Transit Railroad Commissioners for 1902, Chief Engineer Parsons declared: "No changes in design have been found necessary, so that the structure will be completed substantially as planned...."¹⁴⁵ One area where changes were made was the design for the track. The contract specified:

In the underground portions of the railway the track shall consist of rails on a continuous bearing of wooden blocks... The blocks are to be held in place by guard rails secured to metal cross ties imbedded in concrete.¹⁴⁶

In April 1902, when construction had proceeded to a point where track laying could begin, contractor McDonald petitioned the Board of Rapid Transit to change the track specifications. McDonald proposed installing conventionally constructed track, steel rails spiked to wooden crossties on a rock ballast surface.¹⁴⁷ Parsons defended his specifications.

... I believe that a form of track on the line as shown by the contract drawings would, in subway work, be superior to a ballasted track. I believe it would furnish a track with a better line and surface, one making less noise and furnishing the opportunity for the whole of the roadbed to be at all times inspected and kept clean.¹⁴⁸

However, Parsons admitted, "... that such a form of track is somewhat experimental, while on the other hand the track suggested by the contractor is one whose good points have been proved by many years of experience" and recommended accepting McDonald's proposed track. The panel concluded:

... superior advantages can be obtained from the ordinary standard type of track, including less noise greater cleanliness, better distribution of loads, superior facilities for electric connections and the maintenance of proper relation of the third rail to the track, more elasticity, less complication at curves and switches and decreased cost of future maintenance and renewals.¹⁵⁰

The Board subsequently permitted the use of conventionally constructed track in the subway. Diagram 17g depicts a section of the track as constructed and indicates the placement of the third rail used for transmitting electrical current to the motors of the cars.

Within months after Contract One was awarded to John B. McDonald, the Board of Rapid Transit Railroad Commissioners decided to extend the subway into

Brooklyn. The Brooklyn extension began at the end of the two track mainline beneath Park Row and continued south beneath Broadway to South Ferry. Between South Ferry and Joralemon Street in Brooklyn, the two tracks of the Brooklyn extension are carried beneath the East River in two cast iron tubular tunnels. Once in Brooklyn, the line proceeded beneath Joralemon, Fulton, and Willobouy Streets to a terminal at Atlantic Avenue. Diagram 174 illustrates the route of the Brooklyn extension, Contract Two, and the profile of the East River tubes. Contract Two construction was divided into three sections. The geographic boundaries of these sections and the names of the contractors responsible for their construction are found in diagram.¹⁷⁷

Contract Two specified that traffic upon the streets of lower Manhattan not be disrupted. Compliance with this specification required methods of construction differing from those used in Contract One. The contractor proposed replacing the pavement with a planked roadway and excavating beneath this temporary surface. Objections to this method arose from the fear that leakage from gas mains beneath the roadway and within the excavation would produce a devastating explosion. Elevating the pipes above the street permitted the contractor to plank the roadway and proceed with the excavation for the subway.¹⁵¹

Construction of the subway in front of Trinity Church posed the most delicate engineering problem of Contract Two. The 286 feet high Trinity Church spire rested upon a shallow masonry foundation built upon a deep layer of fine sand. This foundation was located nine feet laterally behind the exterior wall of the subway. The bottom of the spire foundation was nine feet below the street, fifteen feet higher than the twenty-four feet deep subway foundation. The fifty-seven feet of subway bordering the Trinity Church foundation was constructed in three sections. Steel channels were used as sheet piling around the subway excavation. These steel channels were left in place after the construction was completed to prevent settlement from voids created by removing the sheet piling. No "measurable or movement of the spire" occurred during or after construction.¹⁵²

Section 2 consisted of the short stretch of two track subway from Bowling Green to South Ferry and the Battery Park turning loop. Section 2-A was the twin tunnels between South Ferry and Brooklyn. The Brooklyn extension crossed under the East River in a pair of single track, cast iron lines, tubular tunnels. These tunnels were parallel and about twenty-five feet apart. The two tubes each had a total length of 6,550 feet and an inside diameter of fifteen and half feet.¹⁵³ As diagram 174 illustrates the 3.1% gradients of the Brooklyn extension tunnels are slightly in excess of those in the Harlem River tunnel of the Contract One subway.

The Contract Two tunnels were driven from double shafts sunk in both Manhattan and Brooklyn. From a shaft at South Ferry, the tunnels were pushed east while, simultaneously, two headings were driven west from a shaft sunk at Joraleman Street in Brooklyn. In driving the Contract Two tunnels, the top heading sequence of excavation was used exclusively. Twelve by fourteen inch timber beams, set five feet apart, carried the heavy sheeting supporting the roof prior to the erection of the cast iron line. Photograph 141 illustrates the timbering of a portion of a Brooklyn extension tunnel.

The initial tunneling east from South Ferry was through rock, so no tunnel shield was required. Shields were required by the sand encountered in tunneling west from Brooklyn. Diagram 163 details the hydraulic shield used in pushing the tunnel west from Brooklyn. All four headings were driven within a pressurized environment. After the headings had been driven approximately 100 feet, two thick brick walls were constructed, with an air locks between them. A thirty-six inch diameter upper lock provided workmen with access to the heading, while a lower lock allowed narrow gauge dump cars to be pulled by a steel cable between the heading and the shaft. Once at the shaft, the excavation bins carried by the cars were hoisted to the surface and emptied.¹⁵⁵

Compressed air powered the rock drills, cast iron lining erector, and grouting machines. Electric lights illuminated the tunnels. Assembling the cast iron lining required the use of a hydraulic lining erector. This device appears in photographs 142 and 143. The erector, "a traveling platform provided with an extensible radial arm pivoting in the tunnel axis and revolving at right angles," was powered by a compressed air motor and traveled on rails affixed to the side of the previously erected lining. Once in position, at the end of the last complete circle of cast iron plates, the radial arm would lift a 900 pound plate and pivot it into the proper position. A hydraulic ram contained within the arm would thrust the ring outward so workmen could bolt it to the already assembled lining. One man operated the device and three others assembled the lining. A grouting machine followed the lining erector. Compressed air forced the grout, a mixture of one part sand and one part Portland cement, through small holes in the lining plates and into the space between the cast iron and the irregularly excavated rock. Threaded plugs were screwed into these small diameter holes to complete the lining of the tunnel.¹⁵⁶ Photograph 147 illustrates the final interior lining of concrete applied to the Brooklyn tunnels.

Section 3 of the Brooklyn extension relied heavily upon reinforced concrete construction. The concrete floor in section 3 is like that of the Manhattan portion of the subway, a thick slab of unreinforced concrete. The walls and roof of the Brooklyn extension, however, are primarily constructed of reinforced concrete and lack steel columns, beams, and girders, except where excessively heavy surface loads were encountered, such as where the subway traveled beneath an elevated railway line. Beneath the columns of the elevated structure, the subway was constructed of "heavy riveted wall and center columns and deep roof beams, girders, and distributing grillages, all of which were completely

enclosed in thick masses of concrete."157 Occasionally, standard bulb angle columns, spaced five feet apart, were used to help support lesser loads. The bulb angle columns found in the Brooklyn extension, like those used in the Lenox Avenue portion of the Manhattan subway, are imbedded in the concrete floor and connected to the horizontal reinforcing rods in the concrete roof.158

The presence of both street car lines and an elevated railway structure made portions of the Brooklyn extension as difficult to construct as any section found in lower Manhattan. In Brooklyn, it was necessary to maintain the street surface, and to underpin a heavy elevated railway structure.

The Brooklyn extension also differed from its Manhattan counterpart in its methods of excavation. Like the subway construction in Manhattan, the first parts of the excavation were made solely with "pick and shovel."159 In section 3 of the Contract Two subway, however, mechanical devices materially sped the removal of rubble. Earth and rubble were shoveled into a hopper which funneled the material onto a series of twenty-four foot long conveyor belts which carried the materials away from the excavation. The belts discharged the spoil into cubic yard buckets carried on narrow gauge railway cars running within the excavation. The cars were pulled along the trench to a point where a hoisting engine lifted the buckets of spoil to the surface and dumped them into gondola cars of the Brooklyn Rapid Transit Company. The street railway line, operating above the subway excavation, transported the cars to a marshy disposal site located off the Brooklyn Company's mainline.160

Although strikes and accidents disrupted the construction of the Contract One and Two subway, neither materially affected the progress or completion of either project. The contract repeatedly specified that the work was to be done by, "skilled workmen." Unlike the construction force, easily recruited from the local population of workmen, the men needed for tunneling, blasting, and hard rock excavating came largely from outside the New York City area. A New York Times article, "Miners Flock to New York," reported, "never until the last twelve months has New York been a mecca for miners."161

More than 600 men worked on the deep rock tunnel in sections 13 and 14, over 400 were members of the Miners Union and, "mostly foreign." Italians, Scandinavians, and Irishmen, worked beside foremen fresh from supervising the construction of railroad tunnels in Colorado; Pennsylvanians, relics of many strikes, full of yarns from the coal mines;" and "Klondikers, boasting of gold they have found and lost again."162

The sub-contractors banded together and formed the Rapid Transit Railroad Contractors Association to formulate a common policy for negotiating with labor. The Rapid Transit Railroad Contractors Association required all workers seeking employment to sign an employment card, "designed as a guarantee to the sub-contractor against future demands by the men."¹⁶³

The cards read:

The undersigned, a citizen of the United States, hereby applies for employment as _____ in the work of constructing the rapid transit railroad in the City of New York, for the compensation of \$ _____ per day, which he represents to be the prevailing rate for a days work in said occupation in the City of New York.

In consideration of which application and representation, _____, hereby employs the undersigned in said capacity at the rate above specified until further notice.¹⁶⁴

The introduction of the cards provoked a "storm of criticism," Workmen feared that by signing the cards they allowed the contractors to pay them less than the union rate.¹⁶⁵

In March, 1901, the New York Supreme Court declared the 'prevailing rate of wage' law unconstitutional. With this decision, the Rapid Transit Railroad Contractors Association withdrew the cards. Harry Seaman, the engineer for sub-contractor Holbrook, Cabot, and Daly, asserted: "The decision of the Court ...no longer binds us to pay the prevailing rates of wages, which, by the way, was not necessarily the union wage..."¹⁶⁶ Engineer Seaman had not only confirmed the workmens' fears that signing the cards permitted the employment of men at wages below union scale, but also raised the specter that without the cards wages would be even less. Seaman, suggested that if the unions would avoid disruptive confrontations and refrain from striking, the contractor would most likely continue paying the existing wages and not implement reductions.¹⁶⁷ He was less conciliatory when discussing the eight hour day:

I believe, and all other contractors I think are with me, that the decision ought to apply to the 8 hour law and that this law will also be declared unconstitutional. It works a hardship to industrious men who want to work overtime. We dare not employ them overtime, though sometimes it would be a great convenience without violating the law.¹⁶⁸

During the height of construction, over 7,770 men were employed.¹⁶⁹ A multitude of local unions represented the skilled workers. The majority of the unions were affiliated with the Central Confederation of Labor Unions. The Central Federation coordinated the political and negotiating activities of many New York City trade unions. In 1900, before construction began, the Central Federation urged the vigorous enforcement of the law prohibiting the employment of aliens on public works projects. The Federation argued that if aliens were permitted to obtain employment, they would, "work for the lowest wages possible, while our own American working men go about starving."¹⁷⁰

The Central Federation sought to act as the voice of all the organized trades involved in subway construction and entered into negotiations with the Rapid Transit Railroad Contractors Association to obtain an all-inclusive agreement on wages and hours.

A strike precipitated by rock drillers in section 5 led to the subsequent agreement between the Central Confederation of Labor Unions and the Rapid Transit Railroad Contractors Association. On May 22, 1901, rock drillers employed by Naughton and Company walked off the job in sympathy with other drillers striking against the Naughton and Company on an outside contract. The rock drillers demanded the contractor pay all his workers the same wages as the rapid transit construction workers. Strict compliance with the eight-hour day and raises to 25¢ per hour for hoist operators were added demands.¹⁷¹

The Central Federation demanded that all men working on the rapid transit subway be abraded into the trade unions that it represented.¹⁷² Confident that the work was far enough ahead of schedule that the contractors could remain inactive without failing to complete the project on time, the Contractor's Association offered only to arbitrate the demands of the Central Federation, ignoring those of the Naughton workers.¹⁷³

Within a week, a tentative agreement between the Federation of Labor Unions and the Contractors' Association was reached. The Central Federation agreed to drop the rock drillers insistence on the unionization of outside contracts, and accept the arbitration of the hoist operators wages. The Central Federation announced that if the Contractors' Association would, "sign the agreement calling for union wages and an 8-hour day on all rapid transit operations, we will instruct our members to return to work."¹⁷⁴ Negotiations over the refusal of two contractors to discharge non-union workmen hired to replace strikers, temporarily delayed the formal acceptance of the two year agreement.¹⁷⁵

The existence of an agreement between the Central Federation and the Contractors' Association did not assure tranquility. The Housesmiths and Bridgemans Union, neither a member of the Central Federation or a party to the agreement with the contractors, was the alleged source of a number of violent acts against sub-contractors.

The Holbrook, Cabot, and Daly Company employed union and non-union workmen on their section of the subway and 'prevailing wages' were paid to all. The engineer for Holbrook, Cabot, and Daly charged that between December, 1900 and September, 1901, the Housesmiths and Bridgemans Union frequently attacked their non-union ironworkers and company.¹⁷⁶ The Degnon-McLean Company, the sub-contractor for sections 1, 2, and 5-A, also experienced "similar troubles" with the same union.¹⁷⁷

The actions of the Housesmiths and Bridgemans Union, however, were not exclusively directed against the contractors. In May, 1902, ironworkers represented by the Housesmiths and Bridgemans Union struck their employer, Terry and Tench Company, the speciality sub-contractor assigned most of the structural steel erection all along the route. The strike came amidst Terry and Trench's attempt to abandon their contract after allegedly suffering financial losses in sections 1 through 4.

The Company argued:

The engineers were too exacting with the ironworkers. They made them do the work 2 and 3 times over sometimes. As we had to pay extra wages for this it was a continued loss and finally we had to give up the contract.¹⁷⁸

Unlike Holbrook, Cabot, and Daly, Terry and Tench's relations with the Housesmith and Bridgemans Union were amicable. A spokesman for the Company reported: "We have been paying union wages all along and had no trouble with the Union." The spokesman concluded that the strike might have been motivated by the Union's desire to see Terry and Trench keep their contract under more rewarding terms.¹⁷⁹

The employment of non-union men alongside of union men, and the introduction of new building materials also provoked strikes and the threat of strikes. In March, 1902, the threat of a strike by the Bricklayers and Masons International Union of America was resolved by an agreement between the union and the contractor limiting the use of concrete in the construction of the 59th Street power house. "Under this agreement, a new power house, which was

to have been constructed altogether of concrete, will be built of brick, and enameled brick will be used at the stations instead of stucco tile."¹⁸⁰

In January, 1904, tilesetters struck in section 3 against the use of non-union men at the 18th Street Station. The company employing the four men argued that its patented process for affixing the tiles necessitated the use of these non-union specialists. The Central Federation of Labor Unions used this issue to call attention to the fact that other, larger sub-contractors employed non-union labor. Since the original agreement between the Central Federation and the Contractors' Association did not cover the installation of equipment by specialty sub-contractors, the completion of the subway generated a confrontation between workmen and contractors over the use of non-union workmen by the sub-contractors installing electrical and mechanical equipment in the 59th Street power house. The use of non-union workmen by Allis-Chalmers, General Electric, and Westinghouse, brought about the threat of a general strike all along the subway.¹⁸¹

These three companies claimed that the installation of the switchboards and steam generators required the use of the non-union company specialists. The unions countered that at the very least the company men, "ought to belong to our union," and that there were in fact, "plenty of people in our union who could do the work."¹⁸² Immediate negotiations and the promise of compromise by the sub-contractors avoided a strike.¹⁸³

With the subway between City Hall and 125th Street poised for opening, a dispute with the bricklayers union erupted. The dispute offered little actual threat of delaying the completion of the subway, but it did prevent the general contractor from announcing the commencement of trial runs. The bricklayers indicated that they intended to strike for an additional 10¢ an hour as soon as the opening of the subway was announced. The contractor delayed scheduling trial runs until work had advanced to a point where he was confident that a bricklayers' strike would not impede the inauguration of operation.¹⁸⁴

Accidents during the construction of the Contract One and Two subway claimed the lives of at least 54 workmen and bystanders and injured at least 300 others.¹⁸⁵ The largest single accident occurred in 1903 on section 14. While the deep rock tunnel beneath 195th Street, was being driven, a large mass of rock, fell upon a group of tunnel laborers, killing ten and injuring another dozen. Earlier, in 1901, a block of rock weighing over 150 tons dropped from the roof of the tunnel at 164th Street and killed 5 workmen.¹⁸⁶ Commenting on the accidents at 195th Street, the Engineering Record editorialized:

Although the accident resulted in the death or injury of over a dozen men, it seems entirely wrong to ascribe it to any lack of care on the part of the contractor and the engineer. Tunneling in heavy rock is always a hazardous undertaking. These who take part in it do so at their peril, even when every means to avoid an accident is taken.¹⁸⁷

On October 24, 1904, the Interborough Rapid Transit Company carried the first fare paying passengers between the stations at City Hall and 125th Street. After a decade of serious planning and another four and a half years of difficult construction, New York City finally possessed a subway. While the Interborough Rapid Transit Company was not the first electrically propelled urban underground railway, it was the prototype for a new dimension in urban transit. The I. R. T. represented true rapid transit, electrically propelled cars, running on an exclusive right of way provided local and express service and avoided the impediments to speed that plagued surface transit.

The construction of the Interborough was also innovative. Steel frame and masonry construction had been used throughout Europe and in Boston prior to its use in I. R. T. The use, however, of reinforced concrete, relatively sparse in Contract I, but extensive in Contract II, demonstrated the economy, practicality, and adaptability of this construction for underground, rapid transit railway structures. Primarily because of the construction of the New York transit subway, "the advisability and advantages" of reinforced concrete were "so complete and so well understood," that by 1909, reinforced concrete had become "indispensable" for rapid transit railway construction.¹⁸⁸ Likewise, on site construction of concrete sewers was first used in reconstructing sewers displaced by the I. R. T. right of way. The experiments with concrete sewers, "gave such satisfactory results that the principle has been extended to other sewers in a similar manner during the year, except that instead of building the arch of brick, as was done at first, the whole sewer in many cases has been built of concrete."¹⁸⁹

However, more than the evolution of concrete construction technology was hastened by the building of the I.R.T. Differences between the methods and rapidity of Contract I and Contract II construction spotlight the advances first made by the I. R. T. which were later applied to general urban railway engineering. While the cut and cover method of construction used extensively in building the Interborough remains the basic method of urban subway construction, refinements in the procedure have reduced the disruption to the surface while increasing the rapidity of construction.¹⁹⁰ Chief Engineer Parsons, in his 1904 "Report" revealed:

"... much more rapid progress has been made on Contract II than on Contract I due to the experience gained on the latter. This was accomplished in spite of the more rigid requirements of the specifications of Contract II, calling for the maintenance of the street surface from curb to curb during construction." 191

Experience gained in excavating for the Contract I right of way provided the engineers with the basis for techniques that improved the rapidity of the Contract II excavation. Along Broadway, planking the full width of the Avenue permitted the uninterrupted excavation and construction of the Contract II right of way with the absolute minimum of disruption to the surface traffic. Mechanization of the excavating, the use of electrically powered conveyors within the trench and, in Brooklyn, the use of street cars to remove large quantities of excavated materials, gives credence to engineering historian James K. Finch's assertion:

To those who recall the building of the first New York subway in 1900-1904 this evolution in methods is particularly striking. 'Parson's ditch' was an open-cut job using hand labor, horse drawn carts, and steam hoists and drills. Street crossings were provided for by temporary wood bridges spanning the cut where, in long sections of open excavation, man and beast toiled with earth and rock. The later extension in lower New York of this first subway marked the change to a complete planking over the streets. Under similar 'decking' with little disturbance to traffic, power shovels and motor trucks have excavated the more recent maze of subways which serve the city. 192

The attention to every detail which characterized the planning and construction of the Contract I subway assured its successful completion and operation. The success of Contract I and the subsequent rapidity of the Contract II construction provided the foundation for the assertion made by the Chief Engineer in concluding his 1906 "Report:"

The years 1905 and 1906 may be regarded as an epoch in the history of rapid transit, looking to construction of future subways on so extensive a scale as to have been hardly conceivable a few years ago, or never contemplated within the past decade. 193

FOOTNOTES

1. T. C. Baker and Michael Robbins, A History of London Transport (London: Allen and Unwin), pp. 113-115.
2. Ibid, and New York Times, October, 14, 1866, p.3.
3. Parsons, Rapid Transit in Foreign Cities, p.8.
4. Ibid., p. 11.
5. Ibid., p. 10, Parsons described the condensing type steam locomotive as one in which, "the steam instead of being blown through the stack, as in done in the ordinary locomotive, is conveyed back into a water tank and there condensed, so that although the smoke and the products of combustion are allowed to escape into the air, exhaust steam is not, and the air is thus kept drier and less disagreeable than it would be if the ordinary type of locomotive were used."
6. "Report of the Chief Engineer," p. 186, in, Report of the Board of Rapid Transit Railroad Commissioners for the year ending December 31, 1900, New York, 1901.
7. New York Times, April 7, 1864, p.8.
8. Ibid.
9. New York Times, December 27, 1865, p.8.
10. New York Times, January 29, 1866, p. 2.
11. New York Times, December 27, 1865, p.8.
12. Ibid.
13. New York Times, February 4, 1866, p. 5.
14. New York Times, March 26, 1866, p. 2.
15. New York Times, January 23, 1866, p. 2.
16. Ibid.
17. Ibid.
18. New York Times, October 6, 1868, p. 4., see also, Sanitary Engineer, July 15, 1886, Vol. 4, #7, p. 153.

19. New York Times, July 8, 1869, p. 5.
20. New York Times, October 6, 1868, p. 4.
21. New York Times, November 29, 1869, p. 2.
22. Ibid.
23. New York Times, February 18, 1869, p. 4.
24. New York Times, January 1, 1868, p. 2.
25. New York Times, April 2, 1868, p. 2.
26. New York Times, March 21, 1870, p. 2.
27. Ibid.
28. Robert M. Vogel, "Tunnel Engineering: A Museum Treatement," Paper 41, United States National Museum Bulletin 240, Smithsonian Institution, Washington, D.C., 1964, 227-231; "Early History of Rapid Transit Enterprises in New York City," Engineering News, Vol. XLVII, #5, January 30, 1902, p. 83-84.
29. Ibid.
30. Some of the proposals presented before the Committee appear in the New York Times, October 23, 1874, p. 3.
31. Report of the Committee on Rapid Transit and Freight Terminal Facilities, Transactions of the American Society of Civil Engineers, Vol. IV, 1875, New York.
32. New York Times, September 24, 1875, p. 8.
33. New York Times, September 6, 1880, p. 5.
34. New York Times, September 15, 1880, p. 8.
35. New York Times, August 17, 1884, p. 9.
36. Engineering News and American Contract Journal, September 5, 1885, Vol. 14 p. 158.
37. New York Times, December 29, 1885, p. 8, for a cross section and an illustration of the proposed road see New York District Railway," News and American Contract Journal, January 2, 1886, Vol. p. 15.
38. Ibid.
39. Sanitary Engineer, January 28, 1886, Vol, 13, #9, p. 199.

39. Ibid.
40. New York Times, March 18, 1888, p. 1.
41. New York Times, April 8, 1888, p. 10.
42. Ibid.
43. Ibid.
44. William B. Parsons' "Rapid Transit in Foreign Cities," (RTFC), provides the most concise descriptions of the transit lines constructed in Liverpool, London, Glasgow, and Paris. "Rapid Transit in Great Cities," (RTFC), pages 6-12, offers a brief comparative description of these systems plus the Buda Pesth underground railway.
45. Parsons, "RTFC," p. 12-17.
46. Ibid., p. 18-20.
47. Ibid., 22-23.
48. Ibid., 25.
49. Ibid., 25-28.
50. Ibid., 36-37, 39.
51. Ibid., 44-46.
52. Ibid., 46.
53. Ibid., 49-50.
54. Parsons, "RTGC," 10-11.
55. Parsons, "RTFC," 51-53. Additional information on the construction and operation of the Baltimore Belt Railroad Tunnel is contained in Engineering News, December 12, and 19, 1891; January 9 and 16, 1892; and May 18, 1893.
56. Ibid., 53055
57. Parsons, "RTGC," 6.
58. Parsons, "RTFC," 59.
59. Ibid., 50, 56-57.
60. William B. Parsons, "Borings in Broadway, New York," Transactions of the American Society of Civil Engineers, XXVII, January, 1893, see also, "Borings for Rock Along Broadway," EN July 18, 1891.

61. "The Report of the Rapid Transit Commission Engineers," EN, October 10, 1891, 341-344.
62. Ibid.
63. Ibid., 341-342.
64. Ibid., 342.
65. Ibid.
66. Ibid.
67. "The Plans for the New York City Rapid Transit Railways", EN, October 24, 1891, 389-393; see also, "New York's Rapid Transit Problem," Engineering Record, (hereafter, ER), Vol 24, #19, October 10, 1891, 299-300; "Rapid Transit for New York," ER, vol. 24, #21, October 24, 1891, 334-335; "New York's Rapid Transit Plans," ER, vol 26, #21, October 22, 1892, 321-2; New York Underground Rapid Transit Plans-I," ER, vol, 26, November 26, 1902, 411-414, "The Rene System of Tunneling for Rapid Transit," EN, February 27, 1892, 204-2-5.
68. "The Report of the Rapid Transit Commission Engineers," EN, October 10, 1891, 344-345.
69. "The New York Rapid Transit Railway, II: Six Years Labor for Municipal Rapid Transit," EN, XLVII, #6, February 6, 1902, 106; see also, "The Latest Plan for A New York Rapid Transit Railway," EN, XXXII, #26, December 27, 1894, 537-538.
70. "The New York Rapid Transit Railway, II: Six Years Labor for Municipal Rapid Transit," EN, XLVII, #6, February 6, 1902, 106.
71. Ibid.
72. "Report on the Modified Routes for the New York Rapid Transit Railway," EN, XXXVI, #20, November 12, 1896, 309; see also, "New York City Rapid Transit Report," ER, vol 34, #24, November 14, 1896, p. 440.
73. Ibid. p. 106-107.
74. "Report of the Chief Engineer, 1900-01," p. 29.
75. Ibid.
76. Ibid.; see also, "Report on the Modified Routes for the New York Rapid Transit Railway," EN, XXXVI, #20, November 12, 1896, 309-311.
77. "Report of the Chief Engineer, 1900-01," 30; see also, "New York Rapid Transit Outlook," ER, XXXVI, #24, November 13, 1897; "The Supreme Court Commission Report on New York's Rapid Transit

77. Railway," EN, XXXV, #11, March 12, 1896, 173-174; "The Outlook for Rapid Transit in New York City," EN, XXXV, #22, May 28, 1896.
78. "Report of the Chief Engineer, 1900-01" p. 30.
79. Ibid., p. 195.
80. "The Contract for the New York Rapid Transit Railway," EN, XLII, #21, November 23, 1899.
81. Ibid.; see also Engineering Record, vol 40, #22, November 23, 1899, p. 498.
82. "Memoir of Arthur Onderdonk," Transactions of the American Society of Civil Engineers,
83. "Report of the Chief Engineer, 1900-01," 196-197; information on John B. McDonald obtained from, "The World's Work, V, #2, December, 1902; N.C.A.B., vol 5, (New York: 1907), 481-482.
84. "Report of the Chief Engineer, 1900-01," p. 226.
85. Ibid., 209; "Report of the Chief Engineer, 1904," p. 231.
86. See "Report of the Chief Engineer, 1900-01," pages 213-220, for a list of the contractors employed to reconstruct sewers.
87. "Contract and Quantities in the New York Rapid Transit Railway Work," EN, XLIII, #21, May 24, 1900.
88. Contract Between the New York City Board of Rapid Transit Railroad Commissioners and John B. McDonald, "Agreement for Construction: Specifications," 67-161; see also, "New York Rapid Transit Railway, III: Contract and Specifications," EN, XLVII, #7, February 13, 1902, p. 127-129; New York Rapid Transit Railway, IV: General Description of the Work," EN, XLVII, #8, February 20, 1902, 161-163.
89. "Agreement for Construction: Specifications," p. 74.
90. "Report of the Chief Engineer, 1900-01," p. 188.
91. Parsons, "RTGC," 11; "Progress of the Boston Subway," EN, XXXVII, #5, February 4, 1897, p. 76-78.
92. "Report of the Chief Engineer, 1900-01," p. 191-193.
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94. Interborough Rapid Transit, The New York Subway, (New York: 1904), p. 38.

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99. "The New York Rapid Transit Railway, V: Sewer Division," EN, XLVII, #12, March 6, 1902, 199-200.
100. "Agreement for Construction: Specifications, Section 17, Sewers," 110-127; New York Rapid Transit Railway, V: Sewer Division," EN, XLVII, #12, March 6, 1902, 199-200.
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102. "New York Rapid Transit Railway, VI: Sewer Division," EN, XLVII, #14, March 20, 1902, p. 236-238; "Report of the Chief Engineer, 1900-01," p. 221.
103. Ibid., 222; see also, "Sewer Reconstruction in New York," ER, vol 44, #1 July 6, 1901, p. 12.
104. "Report of the Chief Engineer, 1900-01," 22-225; "The Contractor's Power Plants on the New York Rapid Transit Railway," ER, vol, #5 August 3, 1901, p. 102-106.
105. "The Construction of Section I, New York Rapid Transit Railroad," ER, vol-51, #10, March 11, 1905, p. 291; "Report of the Chief Engineer, 1900-01." p. 226.
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115. Ibid., p. 206.
116. Ibid., p. 206.
117. Ibid.
118. Diary of William Barclay Parsons, Three volumes, Columbia University University, Special Collections, entry dated June 17, 1902.

119. "Report of the Chief Engineer, 1902," p. 234; "New York Rapid Transit Railway, XI: Contract Section V-A," EN, XLVIII, #14, October 2, 1902, p. 256.
120. "Report of the Chief Engineer, 1902," p. 235-236; "New York Rapid Transit Railway: Contract Section V-B," EN, XLVII, #17 October 23, 1902, 343-345; "Underpinning the Columbus Monument New York," ER, vol 44, #4, July 27, 1901, 77-78; other articles describing the construction of section V are: "The Second Division of the New York Rapid Transit Railroad, Part I," vol 46, #3 ER, July 19, 1902, p. 52-55; "The Second Division of the New York Rapid Transit Railroad, Part II," ER, vol 46, #4, July 26, 1902, p. 81-82; "The Second Division of the New York Rapid Transit Railroad, Part III," vol 46 #5, ER, August 2, 1902, p. 102-103; "Section Five-A, Second Division New York Rapid Transit Railroad," ER, vol 49, #10, March 5, 1904, p. 290-292.
121. "New York Rapid Transit Railway, XIII: Contract Section VIa and Vlb," EN, XLVIII, #20, November 13, 1902, p. 390-393. "Section 5a and 5b, New York Rapid Transit Railway," ER, vol 43, #13, M March 30, 1901, p. 294-296; "Report of the Chief Engineer, 1900-01," p. 236.
122. Ibid.; see also, "New York Rapid Transit Railway, XIV: Contract Section VII," EN, XLVIII, #23, December 4, 1902, p. 478-482; "Section Seven Division Three of the New York Rapid Transit Railroad," ER, vol 48, #12, September 19, 1903, p. 335-339.
123. "New York Rapid Transit Railway, XV: Contract Section VIII," EN, XLIX, #1, January 1, 1903, p. 19-20.
124. Ibid., 20; "Report of the Chief Engineer, 1900-01," p. 239.
125. "The New York Rapid Transit Railway, XV: Contract Section VIII," EN, XLIX, #1, January 1, 1903, p. 20.
126. "Report of the Chief Engineer, 1900-01," p. 239. "Section Nine, Division Three of the New York Rapid Transit Railroad, Part II, The Harlem River Crossing," ER, vol 48, #10, September 5, 1903, p. 268-270.
127. See diagram B; See also, "Section Nine, Division Three of the New York Rapid Transit Railroad, Part I, Open Trench Construction ER, vol 48, #8, August 22, 1903, pages 210-213, for the details of the construction of the approaches to the Harlem River tunnel.

128. "An Economical Method for Subaqueous Tunneling : " a letter to the Engineering Record from D. D. McBean, contractor, section nine of the Rapid Transit Subway, ER, vol 48, #25, December 19, 1903, p. 778.
129. Ibid.
130. Ibid., see also, "Progress on the Harlem River Tunnel of The New York Rapid Transit Railroad," ER, vol 50, #8, August 20, 1904, p. 212-214; "An improve Method of Subaqueous Construction at the Harlem River Construction of the New York Transit Railroad," ER, vol 48, #26, December 26, 1903, p. 814-816; Report of the Chief Engineer, 1902," p. 252-253.
131. "New York Rapid Transit Railway, XVI: Contract Section XI," EN, XLIX, #7, February 12, 1903, p. 147; "Report of the Chief Engineer, 1900-01," p. 240; see also, "Section. 11, 13, 14, New York Rapid Transit Railway," ER, vol 43, #15, April 13, 1901, p. 346.
132. "Report of the Chief Engineer, 1900-01," p. 241; "New York Rapid Transit Railway, XVI: Contract Section XI," EN, XLIX, #7, February 12, 1903, p. 147.
133. Gilbert, p. 21.
134. "New York Rapid Transit Railway, XXI, Contract Section XIII and XIV," EN, XLIV, #24, June 11, 1903, p. 514-515.
135. Ibid., p. 514; "Report of the Chief Engineer, 1900-01," p. 242-243.
136. "New York Rapid Transit Railway, XXI: Contract Section XIII and XIV," EN, XLIX, #24, June 11, 1903, p. 517.
137. "Report of the Chief Engineer, 1900-01," p. 243; "Mining Methods in the New York Subway," The Engineering and Mining Journal, February 1, 1902, p. 176.
138. "New York Rapid Transit Railway, XXI: Contract Section XIII and XIV," EN, XLIV, #24, June 11, 1903, p. 518.
139. Details of this operation appear in: "Widening A Section of the New York Rapid Transit Railway by Moving the Sidewalls," EN, XLVII, #2, January, 1902, p. 26-27; "Moving A Long Tunnel Transversely," ER, vol 44, #25, December 21, 1901, p. 590-591; "Moving A Long Brick Wall," ER, vol 44, #17, October 26, 1901. p. 336.
140. "New York Rapid Transit Railway, XVII: Contract Section XII," EN, XLIX, #8, February 19, 1903, p. 182.

141. Ibid.; "The Manhattan Valley Viaduct of the New York Rapid Transit Railroad," ER, vol 47, #13, March 28, 1903, p. 313-316.
142. "Erection of Manhattan Valley Viaduct,": ER, vol 4B, #6, August 8, 1903, p. 156-157; "The New York Rapid Transit Railway, XVII; Contract Section XII," EN, XLIX, #8 February 19, 1903, p. 182.
143. "Report of the Chief Engineer, 1903," 147; also, "New York Rapid Transit Railway, IV; General Description of the Work," EN, XLVII, #8, February 20, 1902, p. 162.
144. Photograph 6, 139, and 140 illustrates the replacement of the Harlem Ship Canal Bridge. Details of the replacement appear in "Replacement of the Harlem Ship Canal Bridge," Transactions of the American Society of Civil Engineers, LXVII, #1143, p. 3-31.
145. "Report of the Chief Engineer, 1902," 256; "Viaduct Erection on Section 10, New York Rapid Transit Railroad," ER, Vol 50, #15 October 4, 1904, 416-417; "Elevated Structure of the New York Rapid Transit Railroad," ER, Vol 47, #9, February 28, 1903, 220-221; "Erection of the Westchester Avenue Elevated Railway," ER, vol 49, March 5, 1904, p. 287.
146. "Report of the Chief Engineer, 1902,"
147. "Agreement for Construction: Specifications, Section 16, Track, p. 104.
148. Minutes of the Board of Rapid Transit Railroad Commissioners, May 1, 1902, p. 1492-1493.
149. Minutes of the Board of Rapid Transit Railroad Commissioners, September 11, 1902, p. 1731.
150. Ibid.
151. Minutes of the Board of Rapid Transit Railroad Commissioners, September 25, 1902, p. 1771-1772.
152. "Report of the Chief Engineer, 1903," p. 167-168; "A New Method of Tunneling Under Broadway, New York," ER, Vol 4B, #17, October 24, 1903, p. 492-494.
153. "Report of the Chief Engineer, 1904," p. 273-274.
154. A description of the construction of the Battery Park portion of the Contract Two subway appears in "Rapid Transit Railroad Construction at Battery Park, New York," ER, Vol 50, #26, December 24, 1904, p. 732-736. Information on the planning for the Brooklyn tunnels and a general description of the twin tubes is found in "Test Borings in the Bed of the East River, New York,"

154. ER, vol 45, #3, January 18, 1902, p. 53; "Tunneling Under the East River, New York," ER, vol 43, #6 February 9 1901, p. 128. A detailed description of the tunnels and the method used in their construction appears in "The New York and Brooklyn Tunnel for the Rapid Transit Railroad-I," ER, vol 49, #10, March 5, 1904, p. 305-306; "The New York and Brooklyn Tunnel for the Rapid Transit Railroad-II," ER, vol 49, #11, March 12, 1904, p. 329-331.
155. "The New York and Brooklyn Tunnel for the Rapid Transit Tunnel Railroad-I," ER, vol 49, #10, March 5, 1904, p. 304-305.
156. Ibid., p. 305.
157. Ibid., 305-306; "The New York and Brooklyn Tunnel for the Rapid Transit Railroad-II," ER, vol 49, #11 March 12, 1904, p. 330.
158. "Rapid Transit Railway Construction in Brooklyn-I," ER, vol 50, #17, October 22, 1904, p. 448.
159. Ibid.
160. Construction of the Fulton Ave. portion of the Brooklyn extension beneath the Brooklyn elevated railroad is described in "Rapid Transit Construction in Brooklyn-II," ER, vol 50, #18 October 29, 1904, 514-515; "Rapid Transit Subway Construction on Fulton Street, Brooklyn-I," ER, vol 52, #26 December 23, 1905, p. 705-707; "Rapid Transit Subway Construction on Fulton Street, Brooklyn-II," ER, vol 52, #27, December 30, 1905, p. 745-747.
161. "Electric Railways for Grading Work," ER, vol 52, #26, December 24, 1904, p. 736-737.
162. New York Times, April 28, 1901.
163. Ibid.
164. New York Times, March 10, 1901.
165. Ibid.
166. Ibid.
167. Ibid.
168. Ibid.
169. Ibid.
170. "Report of the Chief Engineer, 1904," p. 245.
171. New York Times, January 29, 1900.
172. New York Times, May 27, 1901; Parsons diary, May 22, 23, 24, 1901.

173. New York Times, May 29, 1901.
174. New York Times, May 28, 1901; Parsons diary for May 25, 1901, reveals that the Chief Engineer "urged both McDonald and McNulty to stand firm," in dealing with the strikers.
175. New York Times, June 3, 1901.
176. New York Times, June 4, 12, 16, 1901.
177. New York Times, September 6, 1901; Parsons diary, January 19, 1901, contain one reference to the beating of an iron worker foreman: "Carr (a division engineer), reported that the foreman of the iron working gang had been attacked by union men and very severely injured."
178. New York Times, January 24, 1901; Parsons also reported that contractor Fisher also had unspecified "trouble with the ironmen," Parsons diary, July 12, 1901.
179. New York Times, May 28, 1902.
180. Ibid. Parsons diary indicated that the cordial relationship between Terry and Tench and the Housesmiths and Bridgeman's Union angered the other sub-contractors. His entry for June 26, 1901. reads; "Degnon (a sub-contractor) told of great difficulty in keeping his steel riveters at work on 42nd Street on account of Terry and Tench paying \$3.76 a day."
181. New York Times, March 9, 1902; Parsons diary reveals that as early as March 7, 1901, "a delegation of the Bricklayers' Union appeared before the meeting objecting to the use of concrete and asking that orders should be issued that the electric ducts be laid by bricklayers...."
182. New York Times, January 14, February 1, 1904.
183. New York Times, January 14, 1904.
184. New York Times, January 15, 16, 1904.
185. New York Times, June 22, 1904.
186. "Report of the Chief Engineer, 1900-01, 259; "Report of the Chief Engineer, 1902," 318, indicate that during these three years, 37 workmen and bystanders were killed and 278 injured. Casualty statistics do not appear in the 1903, 1904, and 1905 "Report of the Chief Engineer." A tabulation made from newspaper accounts of accidents related to the construction and operation of the subway during these three years reveals at least 17 were killed and 13 injured, although there is a strong likelihood that a larger number were in fact killed and injured between 1903 and 1905.

187. New York Times, October 25, 1903; New York Times, October 19, 1901.
188. The Engineering Record, vol 48, #18, October 31, 1903, p. 515.
189. Charles M. Mills, "The Applicability and Comparative Cost of Concrete and Reinforced Concrete for Subway Construction," Proceedings of the 5th Annual Convnetion, National Association of Cement Users, vol 5, January, 1909, 262.
190. "Report of the Chief Engineer, 1902," p. 271.
191. S. J. Pirrelli, "Description of Cut and Cover Methods of Subway Construction as Used by the Transit Authority," New York City Transit Authority, May, 1970, 1.
192. "Report of the Chief Engineer, 1904," p. 272.
193. Finch, p. 233-234.
194. "Report of the Chief Engineer, 1906," p. 301.

HISTORIC AMERICAN ENGINEERING RECORD
INTERBOROUGH RAPID TRANSIT SUBWAY (ORIGINAL LINE)

NY-122

"DESIGN AND CONSTRUCTION OF THE IRT: ELECTRICAL ENGINEERING"

Location:	New York City, New York UTM: (Indeterminable) Quad: Brooklyn, Central Park
Date of Construction:	1900-1904
Present Owner:	City of New York
Significance:	The IRT was New York City's first subway.
Historian:	Barbara Kimmelman, 1978.

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ELECTRICAL INTRODUCTION

The New York subway was planned as a rapid transit road. The Commissioners and engineers responsible for its construction meant something quite specific by rapid transit. They meant, first, high speeds. When Alexander E. Orr, President of the Board of Rapid Transit Railroad Commissioners, was asked in 1896 to define rapid transit, he replied that his aim was to provide New York with speeds of 20-25 mph in the business district and 40-45 mph uptown.¹ One purpose of the road would be to "bring the extreme limits of the City into closer relations,"² and only much higher speeds than those offered by existing transit could realize this goal.

A corollary of the need for high speeds was a right-of-way for the exclusive use of the rapid transit road.³ Speed was both dangerous and impossible in the congested business areas, except on a road above or below the street which avoided the hazards and delays of surface operation.

In order to relieve congestion, high-speed cars had to run at frequent intervals. But the speed and frequency of traffic presented problems of passenger safety and comfort, which had to be solved if the road were to be operated successfully.

New York's Rapid Transit Commissioners considered the problem of an appropriate motive power in relation to these requirements - high speed, independent right-of-way, heavy traffic, passenger safety, and comfort. Numerous types of motive power, principally steam, cable, electricity and compressed air, were at this time either in use or proposed for rapid transit systems throughout the world. Each offered technical advantages, each had its own peculiar drawbacks.⁴ The Commissioners, concluded that their requirements demanded electricity. Electric traction was chosen for the New York subway not on the basis of isolated technical considerations, but as an integral part of the projected system of rapid transit as defined by the Commission.

This approach was not widely evident in the decade 1890-1900 when New York's succession of Rapid Transit Commissions gave shape to the future subway system. Rapid transit was seen by some as any type of organized transportation within or around an urban area. In 1891, the Chief Engineer of the Boston Rapid Transit Committee toured European cities to examine rapid transit systems. His report included electric street railways of various types, as well as cable and steam roads. The distinction between surface and rapid transit, crucial to the New York Commissioners, was not important.⁵

Electricity as a motive power often involved the introduction of electricity on existing transit originally powered by different means. This process of electrification undermined the "systems approach" to

motive power choice, stressing instead a commercially competitive comparison of the technical merits of idealized systems.⁶ A common way to classify various transit schemes was by reference to motive power. In 1899 Cassier's Magazine devoted an issue to the electric railway. Articles written by experts in their respective fields considered questions ranging from the development of specific types of equipment to analysis of entire systems.⁷ Overhead trolleys, underground conduits, surface, elevated, and tunneled urban roads, as well as interurban and heavy trunk lines, were discussed. These systems answered different needs, and required different modifications of electrical and auxiliary technologies. The common denominator was electric traction.

The Board of Rapid Transit Railroad Commissioners did not view their problem in this manner. They were not concerned with transforming an existing road to electric power. All engineering aspects of the enterprise were designed "from scratch", giving the Board ample opportunity to realize its systems approach. The fact that in 1891 a tunneled road, rather than an elevated, was under consideration for the new system immediately narrowed options as to motive power. The Board was adamant that steam should not be used on the road, so that the New York subway be spared the hazards and discomfort of smoke-filled tunnels. Electricity and compressed air were the only options considered seriously.⁸ A consulting engineer reported to the Commission in 1891 that the use of electricity would do much to dispel the riding public's prejudice against tunnel transit, and noted recent precedents for this type of system.⁹

European transit systems which might serve as models for New York justified a trip abroad by the Commission's Chief Engineer, William Barclay Parsons, in 1894.¹⁰ Unlike that of his Boston counterpart three years earlier, his report included no reference to surface electric railways. He examined only elevated and tunneled roads, an emphasis suited to the Commission's conception of rapid transit. Electric, steam, and cable operation were all represented.¹¹ Parsons believed the designers of New York's future rapid transit road would learn more, including what not to do, from steam or cable operated tunnel systems than from electric trolley or conduit street practice.

Parsons was distressed by conditions in the tunnel roads powered by steam. He found the air in the tunnels of London's Metropolitan and Metropolitan District Railways "extremely offensive" because of exhaust gases, although the recirculation of steam by condensing locomotives kept the air drier than would otherwise have been expected. The Glasgow City and District Railway, begun in 1888, and the Paris tunnel of the Chemin de Fer de Sceaux, constructed in 1894, were both to be steam operated. Parsons was concerned with the great attention to ventilation demanded by both roads. Parsons suggested another motive power might have been chosen by the Paris company, except that the tunnel was to serve a branch of a steam line and uniformity of service was desired.¹²

Parsons was most interested in electric operation, whether on elevated or tunneled lines. He discussed the operation and the power plants of the City and South London Railway, which had electric locomotives; of the Liverpool Overhead Railway, with motor cars linked in two-car trains with current supplied by steel conduit laid between the rails; of the Waterloo and City Railway, under construction in 1894, the specifics of its electric operation still undecided.¹³ Parsons also took note of two electrically powered American roads, the elevated Intramural Railway built for the Chicago Columbian Exposition, and the seven-mile Baltimore Belt Tunnel of the Baltimore and Ohio Railroad.¹⁴ He persistently found the "important feature," "the most interesting part," "the great feature" of these roads to be the electric operation.¹⁵

Parsons did not embrace electric traction without qualification, nor did he attempt a simplistic evaluation of electric operation. "It cannot be assumed," he wrote, "that electricity has some mysterious properties which render it vastly superior and more economical than steam as a motive power. This idea is fallacious in the extreme."¹⁶ He recognized that "with all things being equal" steam would be more economical than electricity; steam drives a locomotive directly, while a dynamo installation, at great first cost, also required coal and water, plus provided opportunity for power loss in the electric equipment in addition to losses in the boiler and engine.

Parsons knew all things were not equal. Locomotives required the best grades of coal, and conditions on board prevented the most efficient operation of the boiler. A stationary power plant allowed the introduction of equipment, such as steam condensers and fuel water heaters, which greatly increased boiler efficiency. Parsons compared three electric roads, the Liverpool Overhead, the City and South London, and the Chicago Intramural, to New York's steam roads, the Manhattan Company, and the Brooklyn Rapid Transit elevated lines. The three electric roads showed savings in coal consumed and also in coal cost per ton, since poorer grades of fuel could be burned efficiently in the stationary plants. Parsons considered that this "very striking economy in favor of electricity" more than compensated for the greater power losses inherent in the electrical system. Parsons also noted that cost of locomotive repairs per ton per mile were less on the City and South London than on the Manhattan elevated.¹⁷ Although the report simply presented findings without recommendations, Parsons was won over to electric operation. He told the New York press upon his return that the projected subway, with heavy trains running frequently required electric motive power.¹⁸

In December 1894, a few months after Parsons presented his report, the Board of Rapid Transit Commissioners submitted his plans and estimates for the new road to a committee of experts comprised by Abram S. Hewitt, Octave Chanute, Thomas C. Clarke, William H. Burr, and Charles Sooy Smith. The committee members recommended electricity as motive power. They expected electric motors, with their quicker acceleration, to attain higher overall speeds than steam locomotives, thus increasing traffic capacity.¹⁹

Consideration of numerous factors, including motor performance, boiler efficiency, maintenance costs, and tunnel atmosphere were involved in the Commission's evaluation of motive power.²⁰ Although other options were not ruled out, electricity remained the unofficial choice. The official decision was not made until after the contract for the road was awarded to John B. McDonald in 1900. Although the contract did not specify motive power, it restricted the contractor to forms not requiring combustion. McDonald soon petitioned to use electricity rather than compressed air, and the Board approved the choice.²¹

During the mid-1890's the relative merits and applicability of steam versus electricity were widely debated, whether for heavier trunk lines or for street railways.²² The systems approach of Parsons and the Commission made this debate irrelevant to the subway system. Street car and trunk line roads differed widely from each other and from underground lines in purpose and operating conditions. Electricity might indeed have been the appropriate motive power for each, but for different reasons, and its application to each type of road required solution of different problems.²³

The system of motive power and auxiliary technology worked out by the subway engineers was innovative primarily in that it incorporated within one system techniques and practices from other established systems. The electrical system included a single central generating station producing 3-phase, 25-cycle current at 11,000 volts; distribution to sub-stations where voltage was stepped down and current was transformed to direct current; then distribution via cables to a third rail. Power from the third rail was conducted to the car motor by a collecting shoe.

Subway practice therefore took advantage of advances in electric light and power generation and transmission, and very recent practices on other elevated and tunnel roads. The frequency of traffic, and the complexity of track arrangements at certain locations demanded, for greater safety, a system of automatic block signalling and interlocking switching which borrowed heavily from standard steam railroad practice. Application of this system to electric roads gave the subway engineers their most interesting opportunity for innovation. Safe operation also required rolling stock of sturdy framing and fireproof construction. The design of all-steel cars for the subway was the innovative response to this problem. The discussion below, and the technical sections which follow it, will attempt to demonstrate the limited technical contributions available to the subway from electric street railway practice, and the extent to which subway engineers drew upon the experience and extant steam trunk lines and recently constructed rapid transit roads.

The advances in electric traction technology between 1885 and 1900 attracted the attention of rapid transit experts. Uncertainty and controversy surrounded the commercial introduction of electric traction on street and elevated railways in New York. And street railway practice had only limited applicability to rapid transit roads.

New York's surface and elevated lines were the first to experiment with electric traction. The modern successes of pioneers like Charles J. Van DePeople, Leo Daft and Stephen Field, did not immediately win the support of New York's traction men and financiers.²⁴ Before the application of electricity for traction would be commercially feasible, difficult problems required solutions. These included the development of a satisfactory dynamo, transmission of current to the motors from the power source, motor wear-and-tear under the severe conditions of varying speeds and start and start-stop motion, and appropriate mounting and gearing of motors.

The early inventors sought answers, but not until Frank J. Sprague's 1888 installation in Richmond, Virginia, was a commercially successful system devised which incorporated solutions to all these problems.²⁵ Sprague's equipment included single reduction gearing, and a combination of spring and axle support for the motor which was later widely adopted.²⁶ Current was transmitted to the motor via overhead trolley and poles.

Sprague's Richmond installation marked a turning point in attitudes toward electric traction. The 1888 meetings of the American Street Railway Association devoted proceedings to the problem of street railway motive power, and hailed electricity as the motive power of the future.²⁷ But as late as 1894, electric traction was still in New York's future. Other cities and towns had "electrified" eagerly; by 1891 over 200 electric railways had been installed in the United States.²⁸ Amid this rapidly expanding industry, New York's hesitation is noteworthy.

In 1894 the directors of the Metropolitan Street Railway Company decided to install electric service on its Lenox Avenue Line.²⁹ The company viewed the line as experimental; the conduit was constructed to accommodate cable if the electrical service was discovered to be inadequate. By spring of 1895, the General Electric underground trolley system was installed and tested.³⁰ Noting the economies of electric operation and feeling that passengers were pleased with the service, the company planned extensive conversion of much of its system to electricity by early 1897. It was expected that by the end of that year over 40 miles of the metro's tracks would be served by electricity.³¹

The status of electric traction in New York was at this time by no means certain. The success of the Lenox road did not prevent the Metropolitan company from considering compressed air as well as electricity for its 1897 improvements. At the completion of the electric installation, Metropolitan had horses, cable, and electricity powering its cars.³² And the Manhattan Railway Company continued to wait, content with steam-powered locomotives on the elevated lines.

Despite the company's recognition of the superiority of electricity, the persistence of multi-powered operation on the street railways underlines the ways in which street railway and rapid transit service had diverged. The

electric cars of the Metropolitan company operated within a system on which cable and horses served, if not optimally, at least acceptably from the company's standpoint. No trains were operated; all cars ran as single units. While an electric car could move faster than a horse on unobstructed track, the congestion of New York's streets erased this advantage in areas where fast service was most desired.³³ Rapid transit systems with exclusive rights-of-way avoided this problem. On these systems, cars were often hooked together as trains, pulled by an electric locomotive analogous to the steam locomotive, operating at speeds and conditions unfamiliar to the electric street railway.³⁴

In 1897 a crucial innovation in electric traction brought the two classes of electric transportation closer together in one important area-motors. Frank J. Sprague demonstrated his system of multiple unit motor control on the Chicago els, enabling a train to operate electrically without a locomotive, using motors mounted on each car synchronized by controller circuits under command of a motor controller.³⁵ Advances in motor design would now be equally applicable to individual street cars or rapid transit trains. In 1897 William Fransioli, engineer of the Metropolitan Street Railway Company, travelled to Chicago to evaluate the motor performance on the els.³⁶ His trip underscores the importance of multiple unit control in allowing an exchange of technology between street and elevated practice.

Multiple unit control spurred the adoption of electric traction for rapid transit. The equal distribution of weight on the driving wheels throughout the entire train, in contrast to the concentration of weight on the locomotive, made this system suitable for use on elevated structures. Interest finally awakened in New York. Shortly after the initial success in Chicago, the President of the Brooklyn Union Elevated Railroad advertised for bids to transform his lines to electric power, and he expressed a preference for Sprague's multiple unit operation.³⁷

There were numerous methods of conducting electricity to car motors. Street railways relied on overhead trolleys and underground conduits of various designs. During the last two years of the nineteenth century the elevated railways, unfettered by crowded street conditions, began to adopt third rail conduction. Upon his return from the General Electric plant of Schenectady, in 1897, Chief Engineer Cornell of the Brooklyn Elevated was favorably impressed by the third rail he had observed in conjunction with Sprague's new multiple unit system. He felt it would be appropriate for the Brooklyn Bridge crossing; a year later Brooklyn Rapid Transit chose a third rail for its Brooklyn Bridge franchise.³⁸ Third rails were installed on Brooklyn and Boston els, and were used on interurban electric roads as well.³⁹

The flurry of activity in electric rapid transit after 1897 finally aroused the interest of the management of the Manhattan Railway Company. Since the early 1890's, the Westinghouse and General Electric companies had sought in vain to win the important Manhattan contract.⁴¹ Before 1897 the company's hesitance was perhaps justified on technical grounds. But

once multiple unit control and third rail conduction had been tested and found satisfactory in Chicago, Boston, Brooklyn, and other major cities, technical arguments against electricity lost much of their force.⁴²

In June 1898 George J. Gould, president of the Manhattan Railway Company, at last agreed that electric operation would increase the company's earning power, and stem the flood of accusations levelled by New Yorkers against the slow speeds, dirt, smoke, and general nuisance of his road. By early 1899 Gould had not made up his mind concerning the relative merits of compressed air and electricity. In November of that year, however, he finally awarded to Westinghouse the big contract for supplying the electrical generators and equipment for power house and substations. General Electric later received the contract for the motor equipment of the cars.⁴³

The Manhattan company insisted that its earlier actions (or, rather, inaction) reflected due caution, and wariness of untried methods. As soon as others had demonstrated the feasibility of such methods, the Manhattan elevated was quick to follow.⁴⁴ Contemporaries suspected the motives of the Manhattan directorship. The Times said that observers in Philadelphia attributed Gould's actions to the expectation of subway construction in the near future, and that he hoped his improvements would weaken support for the projected rapid transit tunnel. This, coupled with a drop both in revenues and the number of riders which the els had experienced since 1896, could indeed have pushed Gould toward modernization.⁴⁵

The electrification of the Manhattan Railway Company between 1899 and 1902 was important to the rapid transit subway. The Manhattan's conversion paralleled the early years of subway construction. During the planning of the subway system, the Manhattan elevated road combined the most up-to-date practice with close proximity to the subway engineers. Parsons travelled to Europe twice after the tunnel construction began, and he and his staff visited other American cities,⁴⁶ but the Manhattan line provided them with a working model of a rapid transit system in their own backyard.

The role of the Manhattan as a model for the subway was more than a technical artifact to be observed and copied. The Manhattan lines served as a practical working model for the subway. There were similarities in the generating and distribution systems, because the same men drew from their immediate experience and with the els and applied it to the subway.⁴⁷ The electrification of the elevated drew prominent electrical engineers to New York. Some taught the subway engineers; E.P. Bryan, with a background in steam railroading, relied heavily on Alfred Skitt of the Manhattan company for advice on electrical matters.⁴⁸ Lewis B. Stillwell, coming to the Manhattan company direct from his work with high-tension alternating current for the Niagara Power Company, was consultant to the elevated on the design and installation of electrical equipment. In 1902, he became electrical director of the Interborough Rapid Transit Subway Construction Company. He therefore superintended the electrical work for both the elevated and tunneled roads.⁴⁹

Stillwell also brought part of his staff from one company to the other. H. N. Latey worked under Stillwell in the electrical department of the Interborough company, and from 1898 to 1901 he had served as assistant on electrification of the Manhattan elevated. W. C. Phelps, assistant engineer in the Mechanical Department of the Subway Construction Company in charge of structural design of the main and sub power stations, had worked on preparations for the Manhattan electrification.⁵⁰

As the tunnel neared completion, the Manhattan lines, New York's closest approximation to the subway's electrical technology, were used to test rolling stock and motors.⁵¹ The identity between the systems was of course not complete. For example, the Manhattan did not adopt the switching and signaling system desired by the subway engineers, and it was the Boston els which helped with this problem.⁵² But the similarities between New York's elevated and subway systems were an important factor in New York's rapid transit situation. No technical incongruence stood in the way of consolidation and integration of the two systems in 1903, when the Interborough Rapid Transit Company took over the operation of the Manhattan line.⁵³

If the electrification of the Manhattan elevated lines brought the most modern electrical equipment to the attention of subway engineers, the Board of Rapid Transit Railroad Commissioner's attitude assured that the subway would take advantage of the most advanced developments in electric technology. The original contract, as noted above, contained no precise power specifications. The Commissioners felt that "development and progress in this field is so rapid that it has always seemed to the Board the proper course to defer decision in respect to all details to the last moment fixed by the necessity of beginning the operation of trains by a certain time."⁵⁴ This remarkable approach, which recognized that "the whole subject of electric traction is comparatively new," allowed the subway engineers to take full advantage of the changes and improvements worked out by the manufacturing companies competing for the traction market.

The relationship between the electrical manufacturing companies and the New York traction companies is an interesting one.⁵⁵ It has already been noted that manufacturers solicited the attention of the traction interests to the merits of their various machines and systems. The problem of equipping roads as large as those in New York spurred technological progress through interaction between the transit and manufacturing companies.

The electrification of New York's surface roads, els, and subway demanded installations of unusually significant size and nature. The Metropolitan Street Railway plant was described in 1901 as the largest polyphase alternating current railway plant in operation.⁵⁷ The plant of the Manhattan Railway Company, under construction that same year, was expected to be "by far the largest steam-driven electric generating plant in the world." The 59th Street power plant of the Interborough company was larger still.⁵⁸

The contracts awarded to the Manufacturers were correspondingly large. When General Electric received the order for the Manhattan company's motor equipment, it was the largest such contract ever let in the United States.⁵⁹ Allis-Chalmers considered its elevated and subway contracts so important that the company issued a pamphlet advertising its role in equipping of the new systems.⁶⁰ The contracts between the Interborough and the Union Switch and Signal Company were again the largest of the kind awarded to that time.⁶¹

The Manufacturers responded to the needs and demands of the transit system with modifications and innovation. Westinghouse required a specially constructed steel boring machine for the manufacture of the Manhattan company's generating equipment, and both General Electric and Westinghouse modified standard motors to meet the specifications of the Interborough engineers.⁶² Most significant were the signalling system and rolling stock for the Interborough lines; each involved the commercial introduction of large scale innovative designs.

More than one manufacturing company was at work on the problem of applying automatic block signals on electric roads; the Boston rapid transit system had found a solution slightly different from New York's. The Pennsylvania Railroad was interested in the all-steel rolling stock designed for the Interborough⁶³ (see Signaling System and Rolling Stock sections, below). This suggests that the design of large urban and interurban transit systems revealed certain key problems requiring quick and commercially feasible solutions. The interaction of the operating and manufacturing companies in solving these difficulties adds to the importance of the IRT's technical history.

FOOTNOTES

1. N. Y. Times, 8 January 1896, 4:6.
2. Report of the Board of Rapid Transit Railroad Commissioners in and for the City of New York, (hereinafter cited as Commissioners' Report), 1900-01, 185-186 (copy of letter to A. E. Orr, 1 January 1902).
3. Frank J. Sprague, whose many inventions were crucial to electric railway development wrote in Ideal Rapid Transit in 1891 that an independent right-of-way was an essential aspect of rapid transit. (See discussion of Ideal Rapid Transit in March 1891 supplement of Street Railway Journal.) That the notions of rapid transit discussed below were indeed important to the Commission is revealed in the Commissioners' Report 1901, p. 124; the Commissioners, weighing the advantages versus the greater cost of tunnel construction, write, "a road so constructed will be entirely free from danger of collisions with vehicles, will leave the streets above open and can be operated at high speeds with comparatively few inconveniences."
4. Articles comparing the different systems were beginning to appear. See, for example, "The Relative Economy of Cable, Electric, and Animal Motive Power for Street Railways," Engineering News 25 (23 May 1891), 487-489; the Street Railway Journal 11 (24 November 1894), 212, reports opinions of engineers on electricity vs. other powers, with particular reference to New York's proposed underground road.
5. "European Rapid Transit Systems," Street Railway Journal (hereinafter cited as St. Ry. J1. (1891), 678-682.
6. Articles in fn. 4 give a sense of this; even stronger is "The Relative Economy of Electric, Cable, and Horse Railways," Engineering News 26 (24 October 1891), 394; the article reports that at a railway convention, an Edison company staff member discussed electricity as the most economical motive power. Promotional activity by the manufacturers might certainly have produced some biased discussion.
7. Cassier's Magazine 16 (August 1899), Electric Railway Number.
8. Commissioners' Report 1891, p. 115, Proceedings of the Board of Alderman, 28 October 1891. Although by 1902, the choice for electricity was made, the reports of the Commissioners continued to stress the applicability of both electricity and compressed air, and expressed its readiness to consider any other improved motor power provided it would not foul the tunnel atmosphere (see, for example, Commissioners' Report 1902, p. 80). This persistence reflects, not any dissatisfaction with electricity, but the recognition by the Board that choice of motive power was determined by more considerations than simply what was necessary to move the cars.

9. Commissioners Report 1891, p. 64, report of Joseph M. Wilson, consulting engineer. Mr. Wilson gave the particular example of the proposed road in Paris.
10. William Barclay Parsons, Report to the Board of Rapid Transit Railroad Commissioners in and for the City of New York on Rapid Transit in Foreign Cities, N. Y. 1894 (hereinafter cited as RTFC).
11. The Glasgow District Subway, a deep tunnel road, under construction in 1894, was to be powered by cable. RTFC, p. 33.
12. RTFC; in Glasgow, p. 24, in Paris, 44-48.
13. RTFC, pp. 13-16, 18-19, 36-37.
14. RTFC, pp. 51-53.
15. RTFC, pp. 15, 36, 51.
16. RTFC, p. 60.
17. RTFC, pp. 17, 56-63. The success of these very roads discussed by Parsons gave great impetus to the electrification of transit systems. Parsons himself notes in RTFC, p. 55, that the success of the Intramural Railway convinced the management of the Metropolitan West Side Railway in Chicago to adopt electricity. In 1904, Bion J. Arnold wrote that the success of these same roads resulted in "the abandonment of steam and the adoption of electricity on every elevated railway now in operation and practically all of underground roads." See Bion J. Arnold, "The Electrification of Steam Railroads," Proceedings of the International Electrical Congress, St. Louis, 1904, vol. 3, 269-296.
18. N. Y. Times, 3 October 1894, 9:7, 10 October 1894, 4:6.
19. The Committee's evaluation is reported in St. Ry. JI. XI (February 1895), 131-132.
20. The problem of tunnel fouling was publicly stressed the most by the Commissioners, as well as by interested engineers; see St. Ry. Gazette 11 (24 November 1894), 212, reporting the comments of numerous engineers on the proposed system; also, N. Y. Times 24 August 1899, reporting Parson's belief that electricity will overcome the public's "repugnance" to tunnel transit. However, the various Commissioners' Reports of 1891, and 1900-1906 reveal that the Board's decisions were also influenced by the technical considerations mentioned above.
21. Contract For Construction and Operation of the Rapid Transit Railroad between Board of Rapid Transit Railroad Commissioners with John B. McDonald, plus supplementary agreements, 21 February 1900 (original contract, 1899), p. 172; Board of Rapid Transit Railroad Commissioners Minutes 1902, p. 413.

22. See discussion of Theodore Cooper, for electricity, N. Y. Times, 9 February 1896, 10:1; David L. Barnes, for electricity, N. Y. Times, 9 February 1896, 7:1; W. Bucholz, chief engineer of the Erie Railroad, for steam, N. Y. Times, 12 February 1896, 13:4. Louis Duncan and Cary T. Hutchinson, later electrical consultants to the Rapid Transit Commissioners, brought a different emphasis to this debate. Duncan embraced electricity wholeheartedly for both elevated and long trunk lines, N. Y. Times 20 May 1896, 2:6; Hutchinson, more conservative, felt that electrical operation of presently steam-powered trunk lines was "a long way off," and regretted the "indiscriminate lauding" of the third rail system, N. Y. Times, 4 December 1897, 5:4.
23. The important distinctions between these systems was recognized by numerous authors, who, like Parsons, evaluated electric traction within the larger conditions under which it was to serve. Frank B. Lea, "Possibilities of High Speed Electric Traction," Railroad Gazette (21 April 1893), 294-296; Lea is careful to specify the sets of conditions for which electricity is advantageous. Bion J. Arnold does the same in "The Application of Electricity to Steam Roads," (Extracts from the President's Address before the International Electrical Congress, St. Louis, September 14), Railroad Gazette 37 (7 October 1904) p. 414. Contemporary text books also reveal this approach. Carl Hering, Recent Practice in Electric Railways, N. Y. 1897, devotes a separate chapter to consideration of electricity applied to underground roads; H. F. Parshall and H. M. Hobart, Electric Railway Engineering, 1907, specify conditions under which electricity best competes with steam. Clearly the approach of Parsons and the Board, while not prevalent early in the 1890's, was less unique as electrification proceeded and specific problems were identified.
24. The early years of electric railway experimentation and innovation has been discussed intensively both by contemporaries and by later historians. For early accounts, see Robert Luce, Electric Railways and the Electric Transmission of Power, described in plain terms, Boston 1886; Carl Hering, Recent Progress . . ., especially pp. 16-17, listing the achievements and dates of the early experiments. See also Thorburn Reid, "Some Early Traction History," Cassier's Magazine 16 (August 1899), 357-370, and Frank J. Sprague, "The History and Development of Electric Railways," Transactions of the International Electrical Congress, St. Louis, 1904, vol. 3. More recent discussions include E. Alfred Seibel, "Electricity and the Elevated," Bulletin of the National Railway Historical Society 39 (1974), discussing in detail the experiments in New York; also R. J. Buckley, A History of Tramways from Horse to Rapid Transit, North Pomfret, Vermont 1975; also the excellent, scholarly account of Harold C. Passer, The Electrical Manufacturers, Cambridge, 1953, particularly his chapters on electric traction, pp. 216-275.
25. A slower motor was particularly wanted, so that the number of gear reductions between axle and motor could be reduced. For general discussions of technical problems, see Luce, Reid, and Sprague (see fn. 24). More specific are A. L. Rohrer, "Some Early Electric Railway

- Generators," Electrical World and Engineer (hereinafter cited as E. W. and E.) 44 (8 October 1904), 618-621, and Cary T. Hutchinson, "Development of the Electric Railway Motor," Cassier's Magazine 16 (August 1899). Passer provides the best analysis of the situation, stressing Sprague's role as inventor, promoter, but principally as a designer of systems, pp. 236-249, 275. Buckley also stresses this aspect of Sprague's contribution, pp. 59-60.
26. This type of mounting was demonstrated by Sprague to the Manhattan Elevated Railway during his tests in 1885-1886, Seibel, pp. 6-7.
 27. Hering, p. 23.
 28. Hering, p. 34, gives a list of the number of electric railways installed by each manufacturing company. Thomas-Houston led with 103, Edison followed with 83. Westinghouse, concentrating in those years on the development of alternating current motors, and hoping to apply them to traction work, had not yet entered the more commercially practicable direct current traction field. For a list of opening dates of electric railways operating in 1890, see St. Ry. JI. 24, p. 600 (list from U. S. Census Bulletin of 1890).
 29. N. Y. Times, 10 October 1894, 17:4. The article notes that for years observers had deplored New York's "lack of initiative and enterprise in street railways," and hoped the Metropolitan electrification might end such accusations.
 30. St. Ry. Gazette 11 (1 December 1894), 223; St. Ry. JI. 11 (February 1895), 112; N. Y. Times, 9 March 1895, 5:4.
 31. N. Y. Times, 8 February 1897, 10:5, 8 March 1897, 10:6, 5 November 1897, 4:7. It is interesting, and possibly significant, that the electrification on the Metropolitan Street Railway's lines was accomplished during its control by the Metropolitan Traction Company, organized to unify the N. Y. street railways under one management, and dissolved late in 1897 after attaining this goal. See N. Y. Times, 15 September 1897, 12:6.
 32. In 1901, comparisons of the operation of the three different motive powers appeared in print. See, for example, "A 3-year Comparison of Cable, Electrical and Horse Traction in New York City," St. Ry. JI. 18 (5 October 1901), 488.
 33. This indeed was an argument of those opposing electric service in street railways. If high speeds on the street were dangerous, and often unattainable, why bother converting? See, for example, G. Leverich, civil engineer, "Cable and Electric Motive Power on Street Railways Compared," pamphlet, 21 June 1892.

34. Some lines ran two-car trains, with motors mounted on each car, but the greatest advantages of elevated or tunneled roads were achieved with trains longer than two cars. Such long trains were clearly unacceptable on crowded city streets.
35. Further discussion of multiple unit control will be given in Rolling Stock section below, with appropriate references.
36. N. Y. Times, 18 February 1897, 12:6.
37. N. Y. Times, 23 July 1897, 10:2. A large contract was let by the Brooklyn Elevated to the Walker Co. and the Sprague Electric Elevator Co. shortly afterward, N. Y. Times, 24 February 1898, 9:7. Passer, p. 275, writing of multiple unit control, states that "after Sprague it was clear that no elevated railway could continue to use steam power."
38. N. Y. Times, 15 August 1897, 11:2, 23 April 1898, 9:5.
39. N. Y. Times, 14 November 1899, 2:3, 12 September 1901, refer to the earlier installation of the third rail on these roads. For examples of interurban service, see Lewis B. Stillwell, "Notes on the Equipment of the Wilkesbarre and Hazelton Railway," Transactions of the International Electrical Congress, St. Louis, 1904, vol. 3, 340-353, also D. W. Young, "The Third Rail on the Baltimore and Ohio," St. Ry. J. 21 (14 March 1903), 398-405.
40. Of course, the third rail system was by no means necessarily associated with multiple unit control. Third rails had been introduced earlier than 1897, for example, on various trial runs on the New York elevated in the 1880's (see Luce, p. 83), and on Chicago's Metropolitan Street Railway in 1895 (see N.Y. Times, 1 June 1895, 1:5). The two technologies probably became associated precisely because their advantages were limited by street conditions but realizable on roads with exclusive right-of-way.
41. The series of "false starts," reported in the N. Y. Times, going even so far as announcement of contract awards, is quite remarkable: 11 July 1894, 3:6, 27 December 1894, 7:4, 1 June 1895, 5:6, 15 June 1895, 2:1, 14 June 1896, 24:7 (demonstration of Westinghouse a. c. traction system), 3 October 1897 (use of electric motor with a third rail tested on the el), 2 May 1897, 13:1. The fickle indecision of the Manhattan directors was noted by the editors of Electrical World and Engineer (E. W. and E.) 29 (27 February 1897), 279.
42. This is not to suggest that the debate concerning the adoption of these systems did not continue; indeed, the use of the third rail particularly was clouded in controversy for years, making manufacturers like George Westinghouse careful to consider the dangers of the third rail and to point out possible safeguards. See Westinghouse's discussion in The Railway Age 36 (4 September 1903), 288.

43. N. Y. Times, 12 January 1898, 1:4, 2 February 1899, 1:5, 7 February 1899, 12:3, 30 November 1899, 5:3, 2 May 1901, 6:4.
44. N. Y. Times, 3 December 1899, 17:4. The company persisted in this argument; see "the Electrical Equipment of the Manhattan Elevated Railway," St. Ry. J1. 17 (5 January 1901), 1-2.
45. N. Y. Times, 3 February 1899, 8:2, 6 October 1896, 2:3.
46. Parsons' Construction Diary, entry for October 1901 (Parsons in Europe), and 7 July 1902; N. Y. Times, 28 September 1903.
47. Of course much of the similarity also reflected standard practice in such installations. Details of actual input of the elevated into subway practice will be dealt with in the relevant sections below, principally those on the Power House, Sub-Stations, and Rolling Stock.
48. Parsons' Construction Diary, 22 May 1900. Parsons wrote that "Bryan seems to be working with Skitt and taking Manhattan practice as his standard."
49. "Lewis B. Stillwell," National Cyclopedia of American Biography, vol. 14 (N. Y. 1910), 520-521; also letter from Stillwell to August Belmont, 31 October 1900, discussing Stillwell's appointment (copy of letter available at MTA, 1700 Broadway).
50. Information on H.N. Latey from obituary memoir in ASCE Transactions ; information on Phelps from obituary memoir in ASCE Transactions 96 (1932), 1527-1528.
51. N. Y. Times, 16 September 1903, 7:4. The engineering journals also note of these texts; see Rolling Stock section, below.
52. Parsons' Construction Diary, 7 July 1902, reports a trip to Boston by Stillwell, Latey, Bryan and Oeyo, accompanied by a representative of the Union Switch and Signal Company.
53. N. Y. Times, 27 November 1902, 1:1; the lease of the elevated to the IRT became effective on 1 April 1903.
54. Commissioners' Report, 1906, pp. 45-46.
55. Commissioners' Report, 1906, pp. 45-46.
56. Passer, of course, deals with this relationship extensively, with reference to the emergence and growth of electric traction generally.
57. M. G. Starrett, "Notes on the Metropolitan Street Railway Power Plant," St. Ry. J1. 18 (5 October 1901), 407-413.

58. E. W. and E. 37 (5 January 1901) 10-14; "The Largest Steam-Driven Power Station in the World," American Electrician 16 (October, 1904), 501-511.
59. N. Y. Times, 2 May 1901, 6:4. The contract called for 1600 motors.
60. Allis-Chalmers Company, The Power of the New York Subway being the part played by one of the Allis-Chalmers four powers in the Underground Rapid Transit System of New York, Milwaukee, 1904.
61. Railroad Gazette 35 (5 June 1903), 396.
62. N. Y. Times, 2 May 1901, 6:4; Westinghouse Motors for the Rapid Transit Subway," St. Ry. Jl. 21 (21 March 1903), 442-444; "The Type of Controllers and Motors to be used in the New York Subway," St. Ry. Jl. 21 (14 March 1903) 412-4.
63. Railroad Gazette 35 (10 July 1903), 504-505, discussing work of the pneumatic Signal Co. also 35 (5 June 1903), 396; "Automatic Block Signaling on the Boston Elevated," Railroad Gazette 33 (11 October 1901), 692-694.

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THE MAIN POWER STATION

The choice of electricity as the motive power for the New York subway system represented the culmination of one series of careful decisions and the initiation of another. Parsons' early support of electricity did not extend to a preference for a particular type of generating and transmission system.¹ Electric street and railway power houses varied in size, arrangement, and equipment; direct or alternating current could be produced, each requiring different methods of current distribution.² Designing a suitable system for the subway demanded consideration of the conditions and requirements of rapid transit service.

Many of the direct current railway power houses were products of the 1880's and early 1890's, when many small electric lines were springing up, often in connection with direct current lighting companies.³ As the small railways extended their tracks, transmission of current over greater distances was required. The situation of the predecessors of the Brooklyn Rapid Transit Company is typical. Engineers found that voltage drop was great along the d. c. feeders to the far limits of the lines, and voltage boosters were installed at various power stations to assure that sufficient current reached the track. However, d. c. transmission over any great distance, even at the increased voltage, involved a tremendous investment in copper.⁴ As the system expanded and load increased, the direct current generating stations revealed themselves to be costly and inefficient.⁵

With respect to power house equipment, then, the requirements of any extensive urban transportation system, whether surface, elevated or tunneled, were becoming quite similar by the turn of the century. In each case the goal was the same: to produce large amounts of power, and to distribute it to the often far-flung limits of the system's track. This similarity was ultimately reflected in the standardization of railway power house practice. Alternating current, first commercially introduced in stations transmitting current long distances for power purposes,⁶ became the choice of the large urban railway systems. The Brooklyn company had completely converted from d. c. to a. c. by 1904. The power houses of the Third Avenue Railroad Company, the Metropolitan Street Railway Company, and the Manhattan Railway Company, all completed by 1904, produced alternating current at high voltage for transmission to substations for reduction of voltage and conversion to direct current for traction. All were strikingly similar in design.⁷ In this area more than in any other, the designers of rapid transit systems could look to the larger street railway companies as models of standard practice, and all could gain from the recent experience of large alternating current power stations.

Lewis B. Stillwell, the engineer responsible for the design and installation of the Interborough's electric power equipment, was one of the avant-garde involved in developing alternating current for use in urban railways. Before he took on the subway assignment, he was electrical director of the Niagara Falls Power Company, and consulting engineer to

the Manhattan Railway Company during electrification of its lines. The Manhattan Company had obtained the services of W. E. Baker, who had supervised the electric installation of Chicago's Metropolitan West Side "el". However, the company particularly wanted Stillwell because of his experience with large high tension systems, acquired at Niagara and earlier with the Westinghouse Company,⁸ which he applied in the design of the high voltage switching equipment at the Manhattan station.⁹

Stillwell was even better prepared for his work on the Interborough system. He could draw on his Manhattan Railway experience, where he was applying high voltage a. c. technology to an electric traction system. He worked on both projects at once, accepting an appointment as consulting electrical engineer to the subway in 1900. He wrote to August Belmont that "my other engagements will aid, rather than interfere with, my work for your Company,"¹⁰ an assertion borne out by the marked similarity between the elevated and subway power houses, both in system design and in type and make of equipment.¹¹

As part of his work for the Manhattan Railway Company, Stillwell prepared a report analyzing the advantages and disadvantages of various proposals for the power house and distribution system. His recommendations were adopted for both the elevated and the subway, and since no analogous report seems to have been done exclusively for the subway designers, examination of this report is justified.¹²

Stillwell considered nine alternative plans for delivering power, via a third rail, to the Manhattan's car motors. The plans varied essentially in the number of power houses proposed, and whether direct, alternating, or both types of current should be generated. Stillwell rejected both types of combination plant, one with the same generators capable of producing either a. c. or d. c., the other with separate generators producing the different currents, because of the great complexity of the apparatus, the high cost of installation, and the dearth of previous experience with the equipment. Four small d. c. power houses were undesirable, primarily because of increased fire risk, smoke nuisance, and complexity of operation.

Stillwell also rejected two other proposals for direct current generation, each calling for two power houses. One, a 2-wire system with powerful boosters, was out-dated and impractical, similar to the system just abandoned by the Brooklyn Rapid Transit Company. An even stronger objection to this, and to the three-wire proposal, involved the use of the track and elevated structure as the neutral conductor for the system. When large differences in load existed between different parts of the line, the great difference in electrical potential along the structure might prove damaging and dangerous.

Stillwell considered plans for two a. c. powerhouses, one with three-wire and one with two-wire distribution. He rejected the latter plan because of the great cost for copper conductors required by its distribution system. A powerful argument against both was the greater initial cost for construction

and equipment if two power houses rather than one were erected. Stillwell's goals were simplicity and economy of operation, and he believed they would be met by generation from a single large plant.

Indeed, Stillwell vetoed multiple generating stations in all the above proposals. In addition to the greater complexity of this arrangement, the difficulty of finding suitable sites within the city, coupled with the high cost of real estate, argued against multiple generating facilities. The plans he seriously considered called for a single power house. The problem was to determine the most suitable type of current.

Because of the great distance from power house to track, a direct current station required rotary converters at the central plant to produce alternating current for transmission, then a series of substations for conversion back to low-voltage direct current for the third rail. Stillwell saw advantages to this plan; its initial cost was barely more than that of an alternating current station, and most objections to the other plans did not apply here. Starting with alternating current at the generators eliminated the need for power house converters. Current at high voltage was sent from the generators directly to the substations. For Stillwell, the set of rotary converters required in the direct current station represented an additional possibility of malfunction. The increase in the amount of machinery increased cost and, more important, made operation more complex, which he knew was unnecessary in an alternating current station. He also believed a direct current plant limited the system's easy ability to expand capacity, as extra converters would be required for additional power to be delivered at a distance. The simpler alternating current plant would be more cheaply and easily expanded.¹³

A single large alternating current plant required purchase of only one major site and reduced the amount of costly copper needed for the distribution system, and numerous small substations feeding individual sections of track could keep voltage differences along the line at a minimum. Stillwell recommended the construction of a single central alternating current station, and the Manhattan Railway Directors agreed. The station, located at 74th Street and the East River, began operation in 1901.¹⁴

John B. McDonald, the subway contractor, was an early advocate of electricity for subways. But he did not decide on a particular system until late in 1901. By then, Stillwell had been a consultant to the Subway Construction Company for over a year.¹⁵ His work for the Manhattan elevated, as well as his earlier experience with high voltage a. c. generation, must have convinced him to adopt an almost identical system for the Interborough.¹⁶

Stillwell's careful analysis of the faults and merits of the available technologies was, for the most part, as applicable to the subway as to the elevated road.¹⁷ In each case, power was to be provided to a geographically extensive system of track from a central location in mid-town Manhattan. All the arguments concerning the technical advantages of a. c. generation under such conditions were of equal force for the subway. As for the number of power houses to be constructed, the New York real estate market similarly restricted the options of both companies.

One reason the Manhattan Railway Company had settled on a single large generating station was the difficulty of finding an appropriate second site on the West Side of Manhattan.¹⁸ A steam-powered generating plant required proximity to transportation facilities for coal delivery, an abundant supply of fresh water for the boilers (in New York taken from the City mains), as well as cooling water for steam condensing apparatus. It was also desirable to have the power plant close to the center of its distribution area. Riverside locations were ideal in terms of coal delivery (by barge) and access to the river for condensing water. However, when the subway contractor turned attention to this problem in 1901, the choice East River sites were already taken, by the Edison Waterside plant at 40th Street, the Manhattan Railway station at 74th Street and the Metropolitan Street Railway plant at 96th Street. A site much further downtown would at that time have been far from the distribution center of the road then under construction.

The contractor and Rapid Transit Commissioners were forced to consider several less ideal sites. Parsons strongly favored a mid-town location.¹⁹ He opposed the suggestion of a downtown location at 9th Street; he and E. P. Bryan also opposed Long Island City, a location apparently favored by McDonald.²⁰ Locating the station way downtown, or removing it from Manhattan Island completely, would require a greater investment in electrical conduit from the power house to all substations. Late in 1901 McDonald finally purchased a block at 58th-59th Streets, between 11th and 12th Avenues, previously occupied by Switt Company slaughterhouse and refrigeration plants. The site cost more than others under consideration; but expense was secondary to promotional as well as technical considerations. A power station the city could "take pride in" demanded a central location²¹ (for discussion of the architectural design of the power house, see Architectural Report).

John Van Vleck, the mechanical engineer who designed the power station, announced at the time of purchase that he had not formulated final plans.²² However, Stillwell had worked out the electrical system to his satisfaction, and the Manhattan Railway power house was a useful model for the boiler plant as well.²³ By the end of 1901, the major subcontracts for the power house equipment had been awarded to Allis-Chalmers for the steam engines, to Babcock and Wilcox for boilers, and to Westinghouse for the generators and exciters.²⁴

Excavation for the power plant began in April 1902.²⁵ Augustus Belmont saw that the early completion of the station was necessary in order to maintain the projected timetable for the opening of the subway. In March 1902 E. P. Bryan saw to the progress of work at the Westinghouse and Allis-Chalmers shops. He reported that all the subway work was going smoothly, and that four engines and generators might be installed by autumn 1903. Parsons kept watch on the construction, and in January 1904 gave the first tour of the plant to members of the American Society of Civil Engineers.²⁶

The power house was originally 540 feet long, with its west wall closed by a bulkhead to allow for later expansion. During 1902, McDonald received Contract 2 for the Brooklyn extension. He met the anticipated increase in power requirements by enlarging the main power station. By January 1905, the work of extending the building to its complexed length of 694 feet was underway.²⁷

Despite a five-month delay due to labor strikes, four of the projected eleven 5000-kilowatt main generating units were in place, each supplied a battery of six boilers, when the subway began operation in October 1904. These units had for several weeks provided current during rush hours for the elevated lines, demonstrating their fitness for service. By December, two more generating units were installed (see photo 261.), the plant housed 42 boilers and complete installation was anticipated shortly.²⁸

* * *

The structural design of the 59th Street power station was the responsibility of William C. Phelps, who had done similar work on the Manhattan Railway power house between 1899-1901.²⁹ The structure was divided into two essentially separate buildings, the southern half was to house the boiler plant, the northern half the steam engines and electrical equipment (see photo 262). This was a standard design for large steam-operated plants.³⁰ Each "room" extended the full length of the building. Galleries along the north wall of the generating room supported electrical switches and control board, and galleries along the south wall supported the auxiliary steam piping. (see photos 82 and 265). The main northern gallery also housed equipment for a repair and machine shop.³¹

John Van Vleck designed the boiler plant of the power house according to a unit plan which, when the station was completed, divided the plant into six independent functional sections. Each unit contained 2 batteries of six boilers each, feeding two steam engines in the generating room. Power-operated valves disconnected each boiler/engine unit from the main system; any number and combination of units could be operated at a time. For each unit there were also two condensers, one for each battery of boilers, and likewise two boiler-feed pumps, two smoke-flue systems with economizers, and two complements of auxiliary apparatus. The twelve boilers were symmetrically arranged around one of the six chimneys. Five of the units were identical; the sixth broke the symmetry with a steam turbine plant, installed instead of reciprocating steam engines to power the generator for lighting the subway tunnels.³²

The Interborough Company was not the first to adopt such a unit plan in its power house design. The Metropolitan Street Railway plant was arranged to allow for the separate operation of units, even though in practice all machines were operated together. The Manhattan Railway plant was designed for unit operation on a smaller scale than the Interborough; each chimney served two units, each which contained an engine supplied by four boilers.³³ The Interborough scheme was unique in that Van Vleck expanded and developed the idea of unit design by arranging the coal bunkers above the boilers, which were divided by the chimneys into seven separate units. Spontaneous coal combustion could be localized easily, and the plan also allowed for storage of differing grades of coal. The system of steam piping from boiler to engine was also exceptional; the identical steam piping in each unit, according to Van Vleck, gave "a piping system of maximum simplicity, which can be controlled, in the event of difficulty, with a degree of certainty not possible with a more complicated system."³⁴ This simplicity, coupled

with the possibility of independent operation, lent great flexibility to the operation of boilers and engines (see description of steam piping, pp. 15-16). In addition, a section of steam piping, or an economizer unit, might be repaired without closing adjacent sections.

Adoption of a unit design reflected a desire for simpler, more elegant operation, ease of repairs, and flexible use of coal and steam. The latter consideration was key. The cost of coal represented the single greatest operating expense of a steam-powered generating station, and any modification of which resulted in its more efficient use, represented substantial savings. Such modifications could be introduced into the coal circuit, feed water and steam circuit, or condensing water circuit, effecting cuts in the cost of electric power production even before the current passed the switchboards.³⁵ Adoption of the unit plan, and other modifications introduced by Van Vleck, reflected the desire to produce power as cheaply as possible through the efficient burning of coal and economical use of steam.³⁶

The 59th Street power house received its coal via Hudson River barges.³⁷ The coal was unloaded at a 700 foot long, 60 foot wide pier, specially built by the City's Department of Docks and Ferries. Coal was weighed and crushed in an electrically operated hoisting tower at the pier, and deposited on motor-driven 30-inch underground coal conveyors for delivery to the power house.³⁸ Elevating conveyors at the west end of the plant carried coal 110 feet, where 20-inch horizontal conveyors distributed coal to the bunkers. To guard against the accumulation of coal at important junctions, each conveyor in the system ran 10 feet per minute faster than the conveyor that supplied it.³⁹ Automatic self-reversing trippers along the conveyors ensured even distribution to the bunkers.

The independence of the seven bunkers allowed the company to deliver different grades of coal to the different bunkers. A system of distributing conveyors arranged beneath the coal bunkers allowed the plant operators the options of delivering coal from a bunker direct to the hopper beneath it, or of delivering coal to any or all other hoppers along the belt conveyors. High grade coal from one bunker could be delivered during heavy-load periods; when power demands were less, low grade coal from another bunker, or combinations of grades from different bunkers, could be fed to all the boilers. This flexible use of coal, mixing and matching various grades to suit operating conditions, reduced operating costs in two ways: the initial purchase price was reduced, since cheaper grades could be included and stored separately; matching grades of coal to the demands for power meant more efficient consumption of the coal stockpile.

Beneath the boilers, ash hoppers delivered their load to ash cars, pulled by storage battery-powered locomotives back beneath 12th Avenue to the pier for unloading into barges. The distinguishing feature of the entire coal/ash system was its completely automatic operation.⁴⁰

The plant's projected capacity called for 72 Babcock and Wilcox sectional water tube boilers, identical in design to those installed in the Metropolitan and Manhattan Railway plants.⁴¹ Automatic coal handling ended at some of the boiler grates, which were hand-fired from a platform erected between the two rows of boilers. Others were provided with Roney automatic stokers. Within two years, however, the company installed Roney stokers for each boiler, hoping to economize on fuel and labor costs.⁴²

City mains provided all the feed water, since the use of jet condensers rather than surface condensers precluded the recycling of steam for boiler feed. Feed water was heated partly in its storage reservoirs by water discharged from the condensers' hot wells. Further heating was accomplished by economizers, placed in a level above the boilers.⁴³ Hot boiler flue gases could either enter a chimney directly, or at the discretion of the plant operator, pass first into the economizer apparatus. Here heat exchange between the gases and the enclosed feed water sufficiently raised the water's temperature prior to entering the boiler tubes.

The arrangement of the boilers, economizers, and chimneys was the most original and significant feature of the boiler plant. Van Vleck's structural design, complemented by the function of equipment, enhanced both the safety and efficiency of plant operation. Floor space was efficiently used. The giant Custodis radial chimneys did not pass through to the building foundations. They were supported instead by steel columns, their bases raised well above the boiler room floor level.⁴⁴ Space normally required for the chimney bases was therefore available for other uses.

At the Manhattan Railway power house, standard practice was followed in placing the boilers on two levels, one above the other.⁴⁵ At 59th Street Van Vleck used his extra floor space to place all his boilers in two long rows on the main operating floor. The absence of a second boiler level allowed for a higher, well-lit boiler room. Ventilation into the floor above, in addition to the row of windows, helped reduce temperature extremes and the dangers of escaping steam.⁴⁶ The boilers were also installed higher above the floor than was standard, providing for a correspondingly higher combustion chamber with either hand or automatic stoking.⁴⁷ Van Vleck set the economizer units, customarily installed directly beside the boilers, on the upper floor. The removal of economizers and flue connections to another level further reduced the chances of operational disturbances on the boiler floor.

Placing the economizers above the boilers also widened the boiler room while reducing the total width necessary for the installation. Again floor space was freed for new uses. Van Vleck used this space for the steam piping, enclosed in a side gallery between the boiler and generator rooms. By setting the piping apart, with its controlling valves power-operated by men outside the actual area, Van Vleck decreased the danger and nuisance of leaking steam entering either the boiler or generator areas.

A "distinctly new and interesting" steam piping arrangement allowed great flexibility in the application of steam to the engines.⁴⁸ Each group of six boilers fed a steam main which divided upon entering the pipe gallery. From here, steam could follow one of two paths, depending on the valve configuration. Steam could enter two 14-inch mains leading to receivers in the basement, which fed the high-pressure cylinders of the engine' or it could enter a manifold, a system of 12-inch pipes connecting the steam mains of all the boiler groups (see photo 263). With the valves to the manifold shut, each boiler/engine group could be operated completely independently, an especially valuable feature during repair work. With the manifold valves open, the 12-inch pipes acted as an equalizing steam header, distributing steam from all the boilers to all the engines.

A boiler could be disconnected from its corresponding engine, feeding only into the manifolds; likewise an engine could be powered by steam from any boiler. This system ingeniously combined the advantages of the equalizing steam header with those of the unit plan, thereby permitting manipulation of the boiler/engine connections to suit different operating conditions. In this sense the steam piping system was analogous to the coal distribution system beneath the bunkers.

Steam passed from the piping system to the engines in the generating room. The 12,000-horsepower Allis-Chalmers reciprocating engines were "twins", consisting of two compound engines connected by means of a crank to either end of a single main shaft. Each component compound engine consisted of a horizontal high pressure cylinder which emptied steam into a vertical low-pressure cylinder. Both cylinders attached to the single crank at either end of the main shaft. These two cranks were set at different angles, an arrangement providing greater uniformity in the main shaft rotation.⁴⁹

Allis-Chalmers' had first installed this type of engine three years earlier at a Manhattan Railway plant.⁵⁰ Small modifications and improvements had since been made, the most important of which was the substitution of poppet valves for Corliss valves in the high pressure cylinders. The Manhattan engine design had been criticized because Corliss valves were considered inadequate if super-heated steam were employed.⁵¹ The use of the more suitable poppet valves at 59th Street was an important improvement.

The Interborough directors and engineers had considered steam turbines before deciding in 1901 upon the reciprocating engines. They found that conventional turbines did not have the capacity required for the subway power house. Brown, Boveri and Company in Switzerland were the only firm that constructed suitable 3500-kilo watt units. The IRT Company made the conservative choice of reciprocating engines for the traction system, but chose three Westinghouse turbine-generators for the smaller subway and station lighting circuit. Almost immediately, however, the management recognized that advances in turbine technology demanded that any expansion of generating capacity be turbine-generator installations.⁵²

Two Alberger jet condensers served each steam engine (see photo 264).⁵³ Condensing water from the Hudson River entered an oval intake tunnel at a river wall beneath the power house pier, extending under 12th Avenue through solid rock to the eastern 11th Avenue end of the plant. Water was filtered through a series of fine screens behind a coarser steel grillage at the entrance to the intake tunnel. A horse-shoe shaped conduit, built on top of the oval tunnel, served as a discharge tunnel.⁵⁴ At the center of the pier, two timber conduits carried the hot discharge water to either side of the intake screens, to prevent its mixing with the cool water heading for the condensers.

A jet of water entered the condensing chamber through a spray cone. Steam, leaving the low pressure cylinder of the engine, entered the opposite end of the chamber and was condensed by direct contact with the cool river water. The Alberger condensers were of the barometric type, containing a tail pipe with a barometric water column. This column allowed discharge water to flow from the tail pipe into the hot well against atmospheric pressure, keeping air out and thus preserving the vacuum until the next engine cycle.

The use of jet condensers, in which condensate mixed with the spray of cooling water and flowed out through the hot wells, prevented the recycling of steam for boiler feed. Recycling was possible with the use of surface condensers, in which cooling water enclosed in small metal pipes circulated through the condensing chamber. Contact with the cool metal condensed the exhaust steam. In this way condensate was kept separate from the cooling water, and could re-enter the boiler as feed. Where pure water supply was limited or expensive, the recycling of exhaust steam was an important economy.

The Interborough Company which purchased its feed water from the City of New York, might have saved money with the use of surface condensers. Of the three other large railway power plants in the city, however, only one, the Metropolitan, used surface condensers. The Third Avenue Railroad and the Manhattan Railway plants had jet condensers. The objection to surface condensers was the presence in the condensate of lubricating oil from the engines. The water could not be sent to the boilers unless the oil was removed, a difficult and expensive task given the methods then in use. Both the Third Avenue and the Manhattan engineers expected to install surface condensers when a satisfactory method of oil removal was developed, but until then, purchasing clean water from the city was considered more economical.⁵⁵

These same considerations motivated the choice of jet condensers for the main engines of the Interborough plant. But as the Westinghouse turbines of the lighting installation required no oil, surface condensers were more economical. An Alberger counter-current surface condenser served each turbine unit. The cooling water circulated in tubes from the top downward, while the steam entered the chamber at the base. The water of condensation, leaving the chamber at the base, was therefore heated by contact with the entering steam on its way to the feed tanks, eliminating the need for additional heating equipment.⁵⁶

Westinghouse supplied the generating equipment for the power house.⁵⁷ Nine of the projected eleven 5000-kilowatt alternating current generators were in place by October 1904. The generators were direct-connected to the steam engines, with the hub of the revolving field forced onto the main shaft between the two component compound engines of each engine unit (see photo 85). The fly-wheel effect of the revolving field, turning at 75 rotations per minute, helped maintain a high uniformity of rotation without an auxiliary fly-wheel.⁵⁸ Five 250-kilowatt direct-current generators provided 250-volt exciting current for the revolving fields. Three were driven by direct-connection to induction motors, the others by 400-horsepower marine-type steam engines. Current from the exciter plant could also be switched into the circuits supplying the motors for the station's auxiliary machinery.

The generators produced 3-phase, 25-cycle alternating current at 11,000 volts. The armature windings embodies a new design, with the ends of U-shaped copper coil conductors slipped through the armature slots and soldered together to form closed coils. Otherwise the generators were virtually identical in size and design with those installed by Westinghouse in the Manhattan Railway plant.⁵⁹

Stillwell and the electrical engineers chose the 5000-kilowatt generator because a large unit was desired which could still be direct-connected to the engine shaft using only two bearings. Larger units required more bearings for direct-connection, which the engineers deemed inadvisable because of greater opportunity for malfunction. Smaller units did not suit the rapid load changes characteristic of railway service, which required sudden increases or decreases in both the morning or early evening. Plant operation was simpler if one or two large machines were brought on or off the line to effect the desired change rather than cutting in or out many small units. The 5,000-kilowatt unit therefore represented the best size for the plant.⁶⁰

The Westinghouse turbo-generator installation divided the line of alternators at the center of the operating room. The turbines were each direct-connected to a 1250-kilowatt alternator. The total rated capacity of the station, including both the engine and the turbine plants, was 80,000 horsepower. The engineers expected actual effective operation at 100,000 horsepower, and an additional 30,000 horsepower was proposed for the western extension.

Current traveled from the generators through the switchboards for distribution to the substation. The high tension switches were on the main gallery, at the operating floor level along the northern wall. All switches for the 11,000-volt current were operated under oil. The control operator could send current to one of two complete sets of bus bars in brick compartments on the mezzanine floor below the circuit breakers, by closing the appropriate selector switch. The operator overlooked the main generating floor from the switchboard gallery above the circuit breakers, which contained General Electric's generator and feeder control boards, exciter boards, and

control panels for the lighting plant and auxiliary apparatus. Current flowed from the main to auxiliary bus bars and from there to the feeder circuits for the substations. Each circuit was controlled by a type-H oil switch, operated by an electric motor which opened and closed the switch by means of great springs. The operator worked the switch by hand from the control board, but the switch was designed to open automatically in case of overload, as were the alternator switches to the control boards. A time attachment could set the overload relays to open at a pre-determined time, from 3 to 5 seconds, after the overload current began. In this way current would automatically be prevented from flowing through the main switchboard, or along the feeders to the substation, on any malfunctioning circuit. The use of the oil switches, automatic relays, and the arrangement of the control apparatus with respect to the operating floor, underscored the careful attention given to switching control where high voltage was used.

Through the plant, the adoption of the unit plan, combined with Van Vleck's unique arrangement of equipment, brought simplicity and flexibility to plant operation. Along each unit, power flowed smoothly and directly; coal downtakes led to the single boiler level; steam passed from six boilers arranged symmetrically with respect to the engines; along the single line of engines and generators, steam flowed in from the south and electric current flowed out to the north toward the main switchboards. Plants with two tiers of boilers, or multiple lines of engines, could not approach the simplicity of piping and wiring, so important for ease of repairs and operation, achieved at the 59th Street power house.

* * *

After 1904 the Interborough company modified and expanded the plant in response to load growth and the desire to increase the efficiency, and hence the economy of plant operation.⁶¹ Soon after operations began, the company set up a laboratory for coal analysis at the unloading dock. Coal was sampled as it left the barge, evaluated according to company specifications, and a bonus or penalty was awarded to the supplier for an especially good or poor quality. The coal laboratory ensured that the plant furnaces received coal most suited to plant conditions, increasing plant efficiency.

The original sixty boilers were supplied with hand-fired grates. When the installation was completed to 72 boilers late in 1904, the new units had Roney mechanical stokers, and, as noted above, all units had mechanical stokers within two years after operation began. By 1907, expanded transit demands required the plant increase its capacity. Company engineers determined that the installation of additional stokers would provide a 50% gain in steaming capacity per boiler and 18 boilers received additional equipment. This represented a pioneering innovation in boiler practice,

by which increased steaming capacity, with more steam produced per pound of coal, was obtained from a fixed area of heating surface. Economies of space and of fuel utilization were both realized.

In 1909-1910 the company took advantage of the additional capacity by installing five 7500-kilowatt Curtis-type General Electric vertical turbo-generators supplied from the low pressure cylinders of the first five reciprocating units. Surface condensers were installed for each turbine. By taking steam from the engines at close to atmospheric pressure, the turbines increased generating capacity by 15,000 kilowatts without requiring a corresponding increase in the heat of the steam, which constructed a yet more efficient use of coal. The engine/turbine combination was more efficient than any steam turbine then available.⁶²

In 1917 the Interborough extended its track. The company had steaming capacity since 1913 by gradually replacing 42 single and double Roney stokers with 7-retort Taylor underfeed stokers with a greater coal burning capacity.⁶³ After 1917 the substitution was completed, and with the use of induced draft the boilers developed 250% of the original rating. In 1917, the company installed three General Electric horizontal 35,000-kilowatt turbogenerators, the largest and most fuel efficient of this type then available. (see photos 85 and 86). In conjunction with this installation the company provided 30 boilers with superheaters; steam temperature could reach 150° Fahrenheit before entering the engine. The turbines amply increased generating capacity. In 1924, increased steam requirements were met by four additional boilers with underfeed stokers.

Switching and control equipment required modification as the power capacity of the station increased. Modernization in 1915 effectively prepared the way for the 1917 expansion. At this time a central control service, covering the operation of the 59th Street and 74th Street stations and the substations, was set up at 59th Street. Control operators integrated the service of the two large stations to the substations, and kept in contact with the transportation division, dispatching power in accordance with existing load and equipment conditions.

From 1924 until New York City took over the subway in 1940, no significant additions or changes were made in the 59th Street plant. After 1940 the city made studies in order to plan modernization of the power equipment. In 1954 a J. G. White Engineering Company report termed the plant "an engineering museum piece," an "exhibit of primary pioneering in applied engineering as of 50 years ago."⁶⁴ Although the city had finally initiated a modernization program, only one new high pressure boiler/generating unit was installed between 1946 and 1952. Five of the original reciprocating engines were still in operation, in conjunction with old low pressure boilers. Much of the plant equipment, the old boilers, the old switchgear, and the coal and ash handling facilities, were dangerous and inefficient.

In 1959, the City accepted the offer of the Consolidated Edison Company to take over control and operation of the rapid transit power plants.⁶⁵ Con Ed immediately launched a modernization program for the stations (see Inventory, List II for a chronology of Con Ed changes). The 59th Street plant was soon completely overhauled. Of the original equipment little remains. The exhibits of the "engineering museum" were gradually discarded in favor of more modern, efficient equipment.

FOOTNOTES

1. N. Y. Times, 29 August 1895, 9:5. Parsons had not yet decided on a specific type of motor or method of current collection. He said, "These are simple matters, readily adjusted at any time." He was confident that he could use to advantage the experience of the Baltimore and Chicago electric installations.
2. Hartley L. Smith, "Power Generation," Practical Helps for the Electric Railway Shop, Track, Power Generation Line and Rolling Stock Department, N. Y. 1919 articles compiled from the Mechanical and Engineering editions of the Electric Railway Journal. Smith nicely summarized the different types of railway generating facilities.
3. Competition between small local companies could result in duplication of power facilities and street car lines, which might have contributed to the growth of electric railways during the period. See, for example, the case in Atlanta described in the early chapters of Wade H. Wright, The History of the Georgia Power Company, Atlanta, 1957.
4. As the distance of transmission increased, conduction of a proper amount of direct current required wider and wider copper conduits. Passer, pp. 139, 164-167, discusses the relative advantages of d. c. and a. c. transmission.
5. Discussion of Brooklyn Rapid Transit situation from Behrens, Power Supply, contents of chapter 7, pp. 1-6, a fragment of an unidentified work bound in a typescript book in the possession of Mr. Somersville, Power Department, IND division substation, 126 West 53rd Street (hereafter cites as Behrens, typescript; chptr. 7). The book also contains lectures, circa 1950, on technical aspects of the subway system, to be consulted in preparation for promotion exams.
6. Harold C. Passer, The Electrical Manufacturers, Cambridge, Mass. 1953, p. 165.
7. Information on Brooklyn from Behrens, typescript, chptr. 7. The BRT also combined the high voltage generation with substation reduction and conversion. See also Thomas E. Murphy, Electric Power Plants, New York, 1910, and C. E. Roehl, "The Power Stations and Distribution System of the Brooklyn Rapid Transit Company," St. Ry. JI. 18 (5 October 1901), 470-480 for material on the Brooklyn system. For the other power stations mentioned, see William Kent, M. E., "Comparative Review of the Steam Plants of Three Large Electric Traction Main Stations in New York City," St. Ry. JI. 18 (5 October 1901), 441-457.
8. "The Electrical Equipment of the Manhattan Elevated Railway Co.," St. Ry. JI. 17 (5 January 1901), 1-2. The first few pages of this issue introduce a number of articles devoted to the Manhattan system, upon completion of electrification.

9. L. B. Stillwell, "The Electric Power Plant of the Manhattan Railway Company: from the Generators to the Third Rail," St. Ry. Jl. 17 (5 January 1901), 21-47. The high tension oil switching was crucial to so large an a. c. installation. This is stressed in an editorial, pp. 48-49. Stillwell refers several times to Niagara during the article (pp. 21, 25, for example), citing both the similarities and differences between the stations.
10. Letter from L. B. Stillwell, to August Belmont, Esq., President, Rapid Transit Subway Construction Co., 31 October 1900 (copy available at MTA, 1700 Broadway, New York).
11. If one compares the description of equipment of the Manhattan station in Stillwell, "The Electric Power Plant of the Manhattan Railway . . ." with the specifications in the contract between Westinghouse and the Rapid Transit Subway Construction Company, which were drawn up by Stillwell, one sees that he requested and received essentially identical generators (as well as substations transformers and rotaries) for both stations. His familiarity with Westinghouse equipment was undoubtedly helpful here. See Rapid Transit Subway Construction Company, Contract for Electrical Machinery, 4 October 1901, Agreement between John B. McDonald and Westinghouse Electric and Manufacturing Company. Attention will be drawn to additional similarities later in the text.
12. Stillwell gives synopses and selections from his report entitled "Report on Choice of System for Power House," in "The Electric Power Plant of the Manhattan Railway . . ." St. Ry. Jl. 17 (5 January 1901). The discussion which follows is drawn from this article, pp. 20-27. I have not seen a copy of the actual study.
13. Ibid, pp. 26-27, for comparison of the d. c. to the a. c. station.
14. The Print Department of the Museum of the City of New York possesses a remarkable photodocumentation of the construction and equipment of the Manhattan Railway Company's 74th Street power station, taken over by the Interborough Company in 1903. The collection, though extensive (it consists of three cartons of photographs), is untitled and uncatalogued.
15. Commissioners' Report (Proceedings) 1900-1901, pp. 1081-1082, letter from McDonald to Orr on electricity as motive power, pp. 1285-1287: Parsons, Duncan and Hutchinson concur that electricity is most suitable; also letter from Stillwell to Belmont, 31 October 1900.
16. A comparison of Stillwell, "The Electric Power Plant of the Manhattan Railway . . ." with L. B. Stillwell, "The Electric Generating Equipment and Power Distribution System of the New York Rapid Transit Subway," St. Ry. Jl. 24 (8 October 1904), 619-631, will quickly uncover the similarities. These, plus the distinctive features of the Interborough plant, will be described in the technical discussion of the power houses, below.

17. The problem of severe voltage drop along the elevated structure was clearly not a factor here, although drastic differences in electrical potential along the return track circuit could interfere with signal mechanism (see Signaling Section, below).
18. Stillwell, "The Electric Plant of the Manhattan Railway . . .," pp. 26-27.
19. Parsons' Construction Diary, 1 August 1901.
20. Ibid., 15 July 1901, 1 August 1901.
21. N. Y. Times, 27 September 1901, 14:3. Considerations of cost were in this case probably most crucial to McDonald, who had to provide and pay for the site, according to the conditions of his contract. Cost may indeed have motivated his consideration of the Long Island City site. (See Commissioners' Report, 1902, p. 77 for contractor's obligations.)
22. N. Y. Times, Ibid. For example, in 1902 the company was still considering the use of oil as fuel rather than coal (N. Y. Times, 6 June 1902, 13:3). Van Vleck had been manager of Hewitts small New Jersey Railroad, the Greenwood Lake Railroad, in the 1890's.
23. There is evidence, aside from the fact that Stillwell and his staff came to the Interborough from the Manhattan company (see text above and Electrical Introduction), that the similarities between the power stations was not coincidental. Parsons' Construction Diary notes that E. P. Bryan was depending on Alfred Skitt of the Manhattan company for advice on electrical matters (entry for 22 May 1900), and Parsons himself inspected the Manhattan station during construction of the 59th Street plant (entry for 19 August 1902).
24. Commissioners' Report, 1900-1901, p. 259. An interesting note in Parsons' Construction Diary, 28 August 1901: "Lunch with Bryan. Discussed the question of engines. Urged Bryan to accept the Allis-Chalmers bid as being a concern on whom pressure could be brought through Read and Vanderbilt." William A. Read and Cornelius Vanderbilt, as well as James Stillman and Benjamin H. Warner, served on the Boards of both Allis-Chalmers and Belmont's subway construction and operating companies.
25. Minutes, Board of Rapid Transit Railroad Commissioners (1902), 3 April 1902, p. 1445. (Cited: letter of 2 April 1902 from McDonald to Orr).
26. Parsons' Construction Diary, 13 March 1902, 2 April 1902, 3 February 1903, 3 February 1904, 20 January 1904. The company issued its first official statement describing the general structural features of the power house to the ASCE members on the January 20th tour. This statement, reprinted, made up the bulk of an article "The Power House of the Interborough Rapid Transit Company" in The Engineering Record (23 January 1904), 98-99.

27. Commissioners' Reports 1902, pp. 293-294. It was presumably during this additional construction that the sixth chimney was added (see Engineering Record 50 (1 October 1904), 309).
28. "History and Physical Aspects of the N. Y. Subway," Railroad Gazette 37 (16 September 1904), 34; Commissioners' Reports, 1904, report of the Chief Engineer William Barclay Parsons, 1 January 1905, p. 257; N. Y. Evening Post, 28 October 1904, Belmont Scrapbook, Museum of the City of New York. Apparently a tie-line had been installed between the 59th Street and 74th Street power stations, both of which were operated by the IRT (as of 1 April 1903). Later, when the IRT proposed to connect IRT power lines with those of another street railway company, the Rapid Transit Commissioners opposed it, arguing that any present excess of capacity must be reserved for the subway; the Board was able to gain the support of the courts. See Commissioners' Report, 1908, p. 89, also N. Y. World, 20 May 1907 (Belmont Scrapbook).
29. Obituary memoir of William Collins Phelps, ASCE Transactions 96 (1932), 1527-1528. He was also responsible for the structural design of the Interborough substations, repair shops, and car sheds.
30. "Largest Steam-Driven Power Station in the World," American Electrician 16 (October 1904), 501-511, states, "In arrangement the building does not differ materially from that of the larger power plants," p. 501. See also Charles E. Murphy, Electric Power Plants, New York 1910, for descriptions of numerous, quite similar plants.
31. Description of station from "Underground Rapid Transit in New York City," Electrical World and Engineer 44 (8 October 1904), 601-608.
32. Engineering journals devoted many pages to the Interborough system and its various equipments upon the opening of the road in October 1904. Most are extraordinarily repetitive, if not identical. For the power house, the most authoritative source is John Van Vleck, "The New York Rapid Transit Subway: The Steam Generating and Engine Equipment of the Power Plant," St. Ry. J. 24 (8 October 1904), 602-618. It was the first of several articles in this issue on the numerous technical systems of the subway, including the electrical plant, substations, car wiring and motors, and the switching and signaling system. Van Vleck's article was apparently the standard; other journals reprinted it whole or part without denoting authorship. See, for example, "Underground Rapid Transit in New York City," Electrical World and Engineer 44 (8 October 1904), 601-608, and part II, (29 October 1904), 712-729; Coverage in "The Power House of the Subway Division, Interborough Rapid Transit Company, New York," The Engineering Record 50 (1 October 1904), 384-388, pt. I, (8 October 1904), 424-425, pt. II, (15 October 1904), 456-458, pt. III, (22 October 1904), 490-492, pt. IV, (29 October 1904), 510-512, pt. V, (5 November 1904), 541-543, pt. VI. Much of the same information can be found in the Interborough Rapid Transit Company, The New York Subway, New York 1904. More interesting is "Some Features

of the New York City Rapid Transit Company Power House," Power 22 (December 1902), 1-7, published two years before the power house was completed and therefore not simply a duplicate of the company's official statements. The following description of the power house is compounded from these more or less identical sources; only when a piece of information is given only in a particular article, or if one article is exclusively relied upon, will additional citations be given.

33. Starret, "Notes on the Metropolitan Street Railway Power Plant . . ." St. Ry. Jl. 18 (5 October 1901), 407-413; W. E. Baker, "The Steam Plant and Third Rail Equipment of the Manhattan Railway," St. Ry. Jl. 17 (5 January 1901), 10-21.
34. Van Vleck, "The Steam and Generating Equipment . . .," p. 603.
35. Some texts from the period on electric railway operation were valuable aids in understanding the equipment and economics of large power stations. See Samuel Sheldon and Erich Hausmann, Electric Traction and Transmission Engineering, New York 1911; Henry H. Norris, Electric Railways, a Comprehensive Treatise on Modern Electric Railway Practice, Chicago 1913; and the Electric Railway Journal, Practical Helps for the Electric Railway, New York 1919, selected articles from the Electric Railway Journal relating to electric railway practice. Each work devotes great attention to the railway power plant.
36. Once again, the following technical description is taken from the articles cited in fn. 32. Additional citations will be given for additional articles. The text does not attempt a complete or detailed description of the power house; such descriptions are already in print in the journals cited and in the IRT's The New York Subway. Only the more unique or interesting aspects of the power house equipment and arrangement will be discussed here.
37. Although a spur of the New York Central entered the power house at the southern wall near 11th Avenue, this track was used primarily for machinery, and not for coal delivery (Engineering Record (23 January 1904), p. 98).
38. These underground conveyors became controversial. McDonald wanted to close 12th Avenue at 58th Street and build above ground, since the avenue was closed above 59th Street by the yards of the New York Central Railroad. The Dock Commissioner did not approve of this, and Parsons had to play the diplomat between the city agency and McDonald, Bryan and Deyo. He finally suggested that the contractor be allowed to "build over and under 12th Avenue," which the Dock Commissioner approved. See Parsons' Construction Diary, 7 January, 11 January, 13 January, 30 January 1902; also Minutes, Board of Rapid Transit Railroad Commissioners, 13 December 1901, p. 1318. The IRT Company was later censured for constructing such a system of underground tunnels with the permission of only the Dock Commissioner. See Rapid Transit clipping books, 1906-1907, Museum of the City of New York.

39. The conveyor speeds were discussed in "Largest Steam-Driven Station in the World," American Electrician 16 (October 1904), p. 503. All conveyors were provided by the Robins Conveying Belt Company.
40. The coal handling system, partially the bunker arrangement, was considered a noteworthy aspect of the power house by the editors of the St. Ry. Jl. 24 (8 October 1904), p. 501.
41. The water in these boilers was evaporated in tubes of small diameter surrounded by hot flue gases. These tubes were divided into sections containing a vertical bank of 14 tubes each; the Metropolitan Street Railway boilers had 14 sections, those at the Manhattan and IRT plants had 21 sections. See Kent, "Comparative Review . . .," St. Ry. Jl. 18 (5 October 1901), 441-457. Also interesting is that the use of the identical boilers was contemplated and would have been possible, with minor modifications, for burning fuel oil, which was considered for the IRT station (see "Some Features . . ." Power 22 (December 1902), p. 6).
42. That the company provided in its original installation for the ultimate substitution of automatic stokers for hand-firing, as well as the addition of super-heaters between the boilers and the engines, is noted in many of the engineering journals. The quick decision to automate boiler stoking was also noted in the J. G. White Engineering Corporation, Report on the Power Supply of the New York City Transit System, New York 1951, p. 3-4.
43. Feed water heating was desirable because the introduction of cold water into a heated boiler could result in damaging stresses to the equipment, and because evaporating hot rather than cold water required consumption of less fuel per volume of water to be evaporated. See Sheldong and Hausmann, p. 272.
44. This design required a special air-insulating construction of the chimney, to prevent the heating of the steel supports.
45. Behrens, typescript, chptr. 7, pp. 21-22, on Manhattan Railway power house. All the engineering journals suggest that the Interborough arrangement was an innovative departure from standard practice (see "The Power House . . .," Engineering Record 50, part I (1 October 1904), 384), but none state explicitly that no other plant had previously adopted such an arrangement. See also Kent, "Comparative Review . . .," St. Ry. Jl. 18 (5 October 1901), for the New York plants.
46. The Electrical World and Engineer 44 (8 October 1904), p. 603, states that ". . . In this respect this boiler room will be superior to corresponding rooms in older plants . . .," which were ". . . low, dark, and hot during the summer."

47. The higher boiler setting was made with an eye to future modifications, as well. Electrical World and Engineer (ibid, p. 605) wrote ". . . for inclined grate stokers the fire is carried well up above the supporting girders under the side walls, so that these girders will not be heated by proximity with the fire." This was important, as automatic stokers were soon installed (see fn. 42).
48. "Largest Steam-Driven Power Station . . .", American Electrician 16 (October 1904), p. 509. The article states that in the design of the steam piping "the ordinary routine has been radically departed from." The description of steam piping in the text is based on this article. The piping system is also discussed in detail in "Some Features . . .", Power 22 (December 1902), p. 6.
49. For description of the steam engine, see Van Vleck, "The Steam Generation and Engine Equipment . . .", pp. 615-616; also Allis-Chalmers Company, The Power of the New York Subway . . ., Milwaukee, 1904.
50. Kent, "Comparative Review . . .", St. Ry. JI. 18 (5 October 1901), p. 443. Kent writes that the Manhattan engines were (in 1901) "different from those in any other railway power station." The Manhattan engines, smaller than the Interborough's, were rated at 8,000 horsepower.
51. See Kent, p. 447. He predicted at the time that this type of engine, though interesting, would not be widely adopted in American practice.
52. See particularly Van Vleck, p. 615. Turbines were just coming into their own with the advances in a. c. generation and transmission between 1895 and 1900. For a contemporary account, see Edwin Yauger, "The Present Development of the Steam Turbine," Electrical World and Engineer 46 (6 December 1902), 906-908. In November 1904, a critic of the subway power house wrote to the editors of the Engineering Record that the reciprocating engines of the Interborough were "obsolete." (See Engineering Record 50 (5 November 1904), 524. Later installations of turbines in the power plant will be discussed below.
53. Condensers reduce the atmospheric back pressure in the engine piston, increasing the power available at a given steam pressure. See Sheldon and Hausmann, pp. 207-209. The associated circulating and vacuum pumps for the condensing equipment will not be described here. See Van Vleck, pp. 617-618 for a full description.
54. The company built a supplementary discharge tunnel in 1917, north of the original conduits, to take on some of the flow. See Behrens, typescript, chptr. 7, p. 28.
55. Kent, "Comparative Review . . .", St. Ry. JI. (5 October 1901), p. 452. This discussion, of course, refers only to the original installation.

56. "The Interborough . . .," Power 22 (2 December 1902), p. 7; Van Vleck, p. 618.
57. Bids were solicited from Westinghouse, General Electric, and Stanley (N. Y. Times, 12 September 1901, 10:3).
58. L. B. Stillwell, "The Electric Generating Equipment and Power Distribution System of the New York Rapid Transit Subway," St. Ry. J. 24 (8 October 1904), 619-631. The article, which follows Van Vleck's, is the basis for the discussion of the electrical equipment which follows. Other sources are "Electrical Equipment of the Interborough Rapid Transit Company: Subway Division," New York Electrical Handbook, A. I. E. E., 1904, 283-289 (a similar chapter is devoted to the IRT elevated division); also Rapid Transit Subway Construction Company, Contract for Electrical Equipment, 4 October 1901, Exhibit I, alternator specifications. The articles cited earlier also discuss the electrical equipment in varying detail.
59. Stillwell, "The Electric Generating Equipment . . .," p. 620, notes that prior to the Manhattan installation, the use of auxiliary fly-wheels for rotation regulation was standard for large direct-connected units.
60. The analysis is Stillwell's, "The Electric Generating Equipment . . .," 619-620.
61. Information on the later history of the plant is primarily from the J. G. White Engineering Corporation, Report on Power Supply of the New York City Transit System, New York 1951, pp. 1-11; also from Behrens, typescript, chptr. 7, pp. 23-29. The J. G. White study states that, though in the early years changes might have been made to accomodate growth, from 1924 until 1940, when the City of New York took control of the plant, for all modernizations "the impelling motive was economy in power production" (p. 10), such modifications, "generally coincidentally - though not always - meeting the requirements imposed by load growth" (p. 2).
62. The J. G. White Report, p. 6. Company technicians, rather than consultants, worked out the plans for this turbine installation.
63. Dorothy Ellison, in a 3-page typescript history of the 74th Street (Manhattan) station, notes that this plant received these stokers in 1913, as well. The 74th Street plant was also included in the 1917-1919 expansion of service.
64. The J. G. White Engineering Company made reports in 1940, 1946, and 1954, in addition to the 1951 study already cited, all studying the feasibility of modernizing the city's railway power plants. Quotations are from J. G. White Co., Power Supply for the New York City Transit System, New York 1954, pp. 12-13.
65. Several earlier offers, made between the end of World War II and 1954, had been refused. Information on the later changes made by Con Ed is available at the Consolidated Edison Company, 4 Irving Place, New York, N. Y. At Con Ed are held all the original structural equipment and wiring drawings for the power house, as well as some architectural drawings, transferred from the City to Con Ed when ownership changed in 1959.

List I. Electrical Equipment, Interborough Rapid Transit Company.
Detailed specifications and description of selected
equipment of the original installation.

Main Power Station, 59th Street.

Chimneys: 5 (later 6) Alphonse Custodis radial chimneys, 162 ft. high from base (230 ft. above street level), 15 ft. diameter at top, weight 1200 tons, supported by steel girders and columns.

Boilers: ultimate installation, 72 Babcock and Wilcox sectional water tube boilers, 21 water tube sections, 14 tubes high, 6008 sq. ft. heating surface each, designed for working pressure 225 lbs. steam. For 36 boilers, hand-fired Gibson grates provided, grate area 8 ft. deep, 2½ ft. wide, blowers and air ducts beneath boilers (1 blower per 3 boilers, Sturtevant blower driven by direct-connection to a 2-crank 7½x13x6½ inch upright compound steam engine.

Steam Engines: Allis-Chalmers twin compound engines, nominal capacity 8000-hp, actual capacity 12,000-hp at 75 rpm and steam at 175 lbs. at the throttle; shafts of hollow forged open hearth steel; cranks of fantail type, cast steel, crank pins of nickel steel, diameter of shaft at hub of revolving element 37 1/16 inches, main bearings 34 inches.

Alternator generators: Westinghouse, 5000-kw delivering current at 11,000 volts, 263 amps, 3-phase rotating field, stationary armature, height 42 feet, weight 389,000 lbs; speed, with 40 field poles, at 75 rpm, giving 3000 alternations/minute, or 25 cycles per second; at 75 rpm flywheel capacity. 32 ft. high, 332,000lb. field not less than 37,000 lbs. Armature stationary, exterior to field, consists of laminated ring supported by cast iron frame, U-shaped copper bars fit partially closed slots, (4 bars/slot).

Exciters: 5 250-kw direct current Westinghouse dynamos, delivering current of 1000 amps at 250 volts, speed 150 rpm; 3 exciters driven by induction motor, 2 by non-condensing, vertical quarter-crank compound steam engines, built by Westinghouse, Church, Kerr and Co., max capacity 600-hp.

Turbine-Generator lighting plant: 3 Westinghouse steam turbines, multiple expansion parallel flow type, each consisting of two turbines operating in tandem; estimated output per unit 1700-ehp with a steam pressure of 175 lbs. at throttle and 27 inch vacuum in exhaust pipe; guaranteed satisfactory operation with steam superheated up to 450° F.

Power Distribution System of the New York Subway," St. Ry. J1. 24 (8 October 1904), pp. 602-618 and 619-625 respectively; Allis-Chalmers Company, The Power of the New York Subway, Milwaukee 1904; Rapid Transit Subway Construction Company, Contract for Electrical Equipment, 4 October 1901, agreement between John B. McDonald and Westinghouse Electric and Manufacturing Company.

System Sub-stations.

Rotary Converters:	1500-kilowatt, 3-phase Westinghouse Electric and manufacturing Company. D. C. EMF 625, D. C. Amps 2400, Alts. 3000, 250 rpm, 25 cycles, weight 130,000 lbs. Rotary field of low fly-wheel capacity, giving converter great synchronizing power; armature is slotted drum type, with core of laminated steel, armature winding of parallel type; commutator bars of hard drawn copper, insulated by mica, brushes of carbon.
Voltage Transformers:	Westinghouse air blast transformer, 550-kw, 411 volts, 300 Alts., at full load. Air for cooling delivered at 1 ounce per square inch, 2000 cubic feet of air required per minute.
Motor- Generator Starting Sets:	a) Westinghouse Type C induction motor, 3-phase, wound for 3000 Alts., 300-400 volts, 4 poles. b) Westinghouse 4-pole direct current generator, 2-bearing type, directly coupled to motor. Motor and generator mounted on common bed plate.

Data compiled from manufacturers' plates and from Rapid Transit Subway Construction Company, Contract for Electrical Equipment, 4 October 1901, Agreement between John B. McDonald and Westinghouse Electric and Manufacturing Company.

List II. Chronology of alterations at the 59th Street Power House
made by Consolidated Edison since 1960.

From compilation prepared from Annual Reports and employee magazines
by Ms. Dorothy Ellison, Consolidated Edison Co., 4 Irving Place,
New York, N. Y.

- 1959- Con Ed acquires plant, embarks on smoke control program at all
three transit plants.
- 1960- Old low-pressure boilers shut down, reducing smoke emissions
from stacks.
Installation of modern high-pressure boilers.
Interconnections established between 59th Street and other
transit and Con Ed plants.
Labor force for plant operation reduced from 1,200 to less
than 700.
Topping turbines installed (also at 74th Street).
- 1962- Additional low-pressure boilers replaced by high-pressure units.
22,000-kw topping turbine installed.
- 1966- 2 new boilers and 35,000-kw turbogenerator installed.
Single 500-foot stack replaced western-most four 240-foot
stacks (preliminary to gas turbine installation).
- 1968- Plant completely converted from coal to oil and gas fuel.
- 1969- \$53 million spent in modernizing the three transit plants
in previous decade.
Consolidated Edison uses steam from the transit plants to
supply steam system.

A good sense of detailed changes made by the Interborough
and by the City prior to 1959 can be gained from the revision
boxes of the vast number of tracings held by Con Ed at 44 Irving
Place. A loose text book of reduced, xeroxed copies of all the
drawings at Con Ed is available at the Transit Authority Power
Department Office, IND substation, W. 53rd Street, New York, N. Y.

THE POWER SUB-STATIONS

Electricity generated at the 59th Street power house for use in the subway went first to the eight original sub-stations, most of which are still in operation today.¹ Here power was altered, processed, packaged, and put into a form appropriate for the job it had to do in the tunnels. Here also were air compressors, supplying the electro-pneumatic signaling and switching installations.

Transmitting high voltage alternating current from a main power house to sub-stations for conversion to lower voltage direct current suitable for the car motors was a relatively new practice in railway work.² It took advantage of recent advances in alternating current technology, particularly the development of a satisfactory 25-cycle rotary converter, first introduced by Westinghouse in its Niagara installation just a few years before.³ The use of alternating current, requiring less copper conductor and resulting in lower transmission cost, allowed the economical and efficient transmission of power to sub-stations spaced approximately two miles apart along the subway route.

Because suitable real estate was difficult to find in the built-up downtown areas, contractor McDonald suggested that some of the sub-stations be placed underground. In February 1901 he requested the aid of the Rapid Transit Commission in acquiring the right to excavate under public lands at City Hall Park, Union Square, and Longacre (Times) Square. McDonald's contract made him responsible for the purchase of all lands for power facilities and he hoped to cut down his expenses by using city rather than private property. After consulting its lawyers, the Board decided that it lacked authority to grant this request. McDonald had to build his sub-stations above ground.⁴

It was desirable to have the distribution distance to the subway as short as possible after conversion to direct current at the sub-stations. In the downtown areas McDonald obtained sites no more than one-half block from the route. In the far less crowded up-town locations (see photos 270 and 7), the Simpson Street and the Hillside Avenue sub-stations were nearly adjacent to the track.⁵

Two adjoining city lots, each 25x100 feet had to be purchased to house sub-station equipment. The resulting 50 foot width allowed installation of eight to ten rotary converters with their sets of transformers. In sub-station #13 on West 53rd Street, foundations were laid for ten rotaries; the remaining seven were built to receive eight rotaries.⁶

Foundations for eight to ten rotary converters was a provision for the future. The original 1901 Westinghouse contract called for only 26, 1500-kilowatt rotary converters, or four to five per sub-station.⁷ (See Table B for data on original installation). In 1909 Westinghouse responded to a second call, this time for 3,000 kilowatt units. In the plans for the 1916-1918 general system expansion (see Power House section) additional contracts to both Westinghouse and General Electric provided 4,000-kilowatt rotaries, some of which replaced the older 1,500-kilowatt machines.⁸ During expansion,

sub-station 11 at Park Palce was demolished, and its replacement, a half block from the original site was equipped with 4,000-kilowatt units. In 1923 additional 4,000-kilowatt General Electric and Westinghouse units were installed⁹ (see Inventory, Table 8, for synchronous converter installations, by sub-station).

The remaining seven of the original eight IRT sub-stations are still standing. Number 19 on West 132nd Street is no longer in use and its equipment has been removed. The others still operated daily with equipment from the earliest installations.

* * *

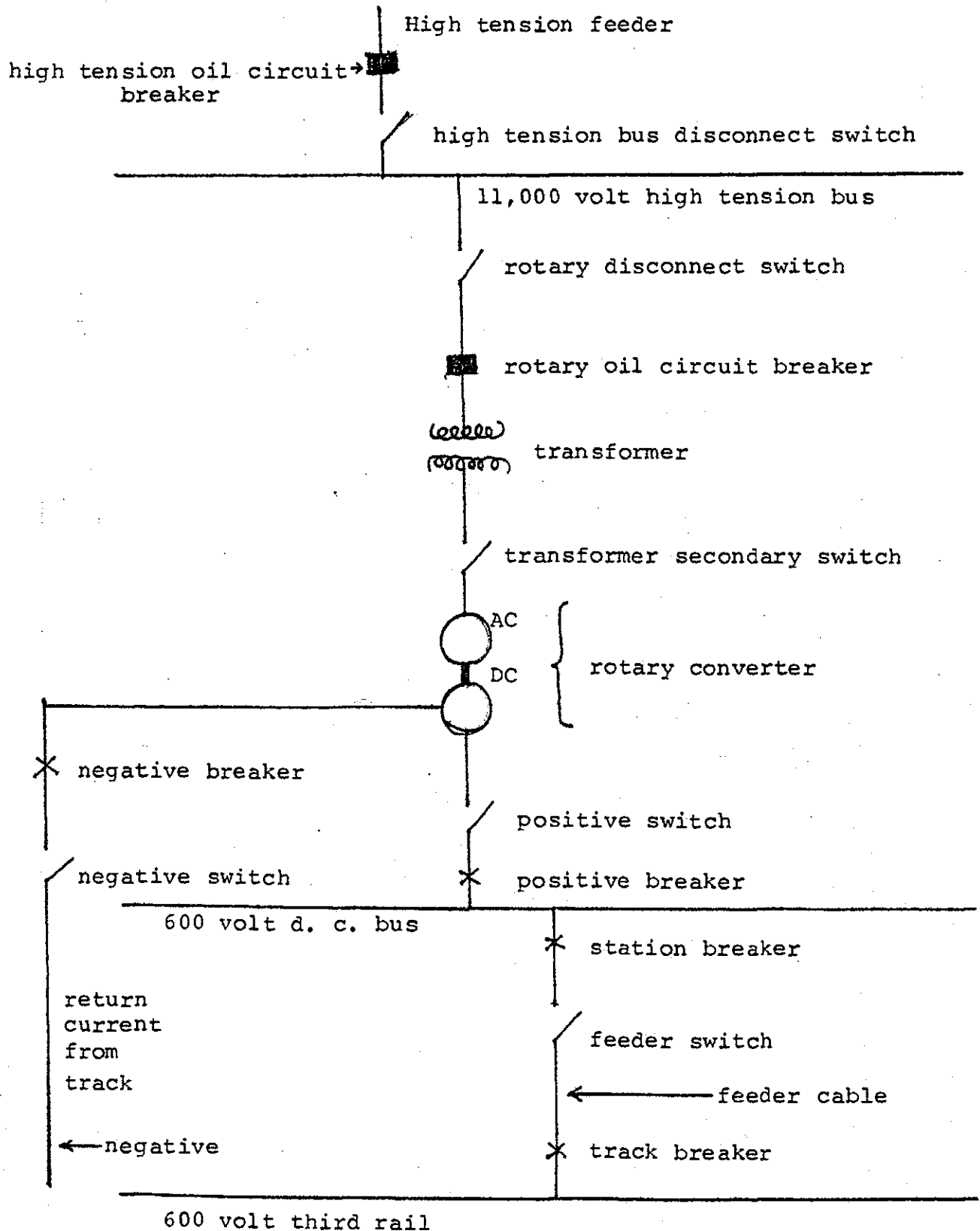
At the 59th Street power station 11,000-volt, 3-phase, 25-cycle alternating current destined for the sub-stations passed along single conductor cables to the main switchboards. From here high tension feeder cables, with three strands of copper conductor each carrying one phase of the current, extended through vitrified clay ducts from 11th Avenue under 58th Street to the subway structure at Broadway. Paper insulation separated the three conductors. The cables were 000 Bond S gauge, sheathed with lead. Insulating rubber placed between the sheaths protected them from electrolysis.

The side walls of the subway tunnel contained 64 ducts on either side of the subway, stacked 32 ducts high and 2 ducts wide. Through these ducts the a. c. cables extended through the tunnel to the sub-stations. At each passenger station the side walls receded sharply. Following this path with the cables would have unnecessarily increased transmission distance. The subway engineers therefore routed the cables beneath the station platform, effectively turning them on their side; beneath the platform the ducts were 32 wide and 2 high. At the end of each platform the cables re-entered the side wall, adopting their original configuration.¹⁰

At each sub-station the cables ran from the subway to a manhole, or vault, at the front of each sub-station building. They followed tiled ducts to the rear of the stations, which carried them directly under their proper oil switch, where each of the three conductor strands attached to one of the three fixed terminals of the switch. The oil switches included a motor-operated reverse current relay between the incoming cable and the bus bars, which opened the switch in case of short circuit. This, coupled with the action of the overload time delay relays at the a. c. feeder switches at 59th Street, would disconnect the cable from the power house and sub-station during any disturbance on the line. This protected adjacent cables from possible damage, and allowed much of the station operation to continue unaffected.¹¹

The pathway of current through the sub-station was protected at every crucial point with similar oil circuit breakers. From the incoming a. c. circuit breaker, current passed through a disconnect switch to the 11,000-volt high tension bus (follow current pathway with Diagram I, p. 5). As noted above, the connections at the switches maintained three distinct conductors for each phase of the current; each conductor carried current, through another disconnect switch and oil circuit breaker, to one of a bank of three single-phase transformers. The voltage of each phase was therefore separately reduced. Current at 550-600 volts passed through another switch to the

Diagram I: Pathway of current between
substation and third rail



three-phase rotary (see photos 272 and 273), which converted the alternating current to direct current and sent it through a switch/breaker set to the direct current bus.¹² From here a feeder cable carried the 600-volt propulsion current to the third rail.¹³

EQUIPMENT ARRANGEMENT

The arrangement of equipment was identical in the eight original sub-stations.¹⁴ On the main floor were the rotary converters, arranged in two parallel rows along the building's length. Placed between each rotary and the nearest side wall was its bank of three transformers (see photos 272 and 265).¹⁵ A raised gallery at the rear of the building supported the control and switch boards and the d. c. feeder oil circuit breakers (see photos 257, 267 and 272,

The high tension a. c. cables passed from their entrance vault along a basement wall to the high tension breakers, located on the main floor beneath the gallery. These were operated by heavy springs wound by an electric motor (see photo 273).¹⁶ The high tension bus, carried in brick compartments, cut the building along its width on the main floor. Cables extended from the bus to the a. c. panel board in the gallery.

From here, conductors returned to the main floor to bring current to the voltage transformers. These machines were air cooled.¹⁶ In the basement, an air chamber extended beneath each longitudinal row of transformers (see photo 187). A motor-driven blower at the head of each chamber filled it with air slightly above atmospheric pressure. This pressure pushed cool air upward through passages to the transformer buses. Air flowed through the coils and out the top of each transformer unit.¹⁷

Each rotary converter stood in its own hard-wood frame (see photos 272 and 84). The frame was not bolted to the Portland cement foundations; the rotary weight was expected to hold the unit in place. The rotaries were the heaviest equipment of the sub-station. Two hand-operated cranes, at the front of each sub-station on the main floor, were provided for the rotary installation and service¹⁸ (see photo 265).

The rotary converters could be started in one of two ways. By switching the conductors of the d. c. side of a rotary into a direct circuit to the d. c. bus, a station attendant could start the rotary as a d. c. motor. A special starting control panel in the gallery contained the appropriate switches. When the panel instruments indicated that the rotary had reached a speed synchronous with its transformers, the attendant threw the switch connecting the transformers to the a. c. side of the rotary.

If the sub-station had been entirely shut down and the d. c. bus were dead, the rotaries could be started from a motor starting set. Each set consisted of a 3-phase induction motor direct-connected to a d. c. generator,

mounted together on a common base. The motor had enough capacity to start all the rotaries in the sub-station, although once one was started and put on-line, the rest could be started from the d. c. bus.¹⁹

The direct current switch boards extended across the width of the gallery (see photo 3). The oil circuit breakers for the d. c. feeders were located in individual brick compartments facing the d. c. switch boards, with each breaker directly opposite the hand-operated switch which closed its particular circuit (see photos 266 and 269). Company engineers believed this arrangement was first introduced in the IRT sub-stations. The isolation of each d. c. feeder breaker protected the others from damage should a breaker open automatically due to a short circuit.²⁰

The General Electric Company provided the instrument panel mounted on iron columns above the switches and control boards (see photo 272). The three feet between the instruments and the bench board allowed the plant attendants to view the operating floor while working at the controls (see photo 3). The d. c. feeder cables carried current from the gallery to the basement and extended through ducts to the subway structures.²¹

The sub-stations were responsible for much more than provision of the propulsion current to the third rail. High voltage alternating current from the 59th Street turbo-generator installation, intended for tunnel and station lighting, was routed first through voltage transformers in the sub-stations. The reduced current did not pass through a rotary converter; it went directly to a second transformer within the tunnel, which further reduced the voltage to the level required for the lighting and auxiliary power circuits. In addition, all power for the electro-pneumatic signaling and switching installations originated at the sub-stations. Motor-generators provided alternating current for the signals' track relay circuit; Ingersoll-Sergeant air compressors (see photo 274) supplied the pneumatic cylinders which controlled the movements of switches and signals.²² See Signaling, Switching and Safety section.

Although the appearance of the original IRT sub-stations was neat and symmetrical (see photo 257), the current pathway was somewhat confused and indirect. Cables carried electricity from front to back, from level to level. Engineers were beginning to recognize, however, that at least for small installations, the advantages of a raised control gallery were outweighed by those of placing all equipment on one level. An energy pathway as direct as possible from the incoming high tension feeders to the outgoing d. c. cables minimized confusing connections and simplified station operation. The newer sub-stations built during the 1916-1918 system expansion abandoned the old design; and all transformers, rotary converters, and switch and control panels stood on the main level.²³ The original sub-stations were the only ones built by the IRT with raised switch board galleries.

* * *

The original sub-stations have changed remarkably little as the New York subway system changed and expanded. As noted above, the need to increase the stations' current-handling capacity resulted in two additional rotary converter installations, with the necessary transformers. Each time, the capacity of the new rotaries was higher, 3,000-kilowatts in 1909 and 4,000-kilowatts in 1916 and 1923. However, since provision had been made for additional installations, and because the 4,000-kilowatt units were actually smaller in size than the older 1,500-kilowatt machines, the new equipment fit neatly into the sub-stations without interfering with the original design.

The IRT did make some changes in the sub-stations to accommodate expansion. The sub-station at Park Place was replaced, relocated, and equipped in 1917, as already noted, with higher capacity equipment. The same year the west back wall of sub-station 12 was extended through the next lot, making space available for offices and allowing extension of the gallery.²⁴ In 1919, substation 13, at 53rd Street, which was built with greater capacity than the others, received a new switch board. In its downtown location, it was expected to carry much of the increased load of the system.²⁵

Although the Consolidated Edison Company took control of the 59th Street power station in 1959, the Transit Authority retained control of the power sub-stations. The Transit Authority had by this time determined that mercury-arc rectifier units, without troublesome moving parts and more efficient at light loads than rotary converters, would take on all expansions in load. Today solid-state rectifiers are expected to replace the old rotary units, and the original sub-stations will be phased out of the system.²⁶ Control panels for the new units are presently located on the galleries of the sub-stations.

The downtown sub-stations handle not only IRT lines, but lines which were originally part of the BMT system. They generally operate 24 hours a day. The uptown west-side Manhattan stations still serve only the original Contract I IRT route. The sub-stations at 143rd Street and at Hillside Avenue contain only equipment from the original 1901 Westinghouse contract; the early system expansions did not affect the load on the far-flung stretches of track. The plant attendants operate these stations much as their predecessors did in 1904. The rotaries are manually cleaned and serviced. Only the blinking lights on the recently installed mimic boards and rectifier control panels (see photo 268) reflect the subsequent modernizations of the system.

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These uptown sub-stations are in use only during rush hours and other peak load periods. They will be the first of the original sub-stations to be abandoned and dismantled.²⁷ As long as they are used they will continue as "operating museums", the most important equipment remaining from the original IRT installation.

FOOTNOTES

1. "Underground Rapid Transit in New York City - Part II," Electrical World and Engineer (E. W. & E.) 44 (28 October 1904), p. 721-729. The distribution system as originally conceived involved 12 sub-stations; only eight were actually built (p. 721). A ninth similar, sub-station was built at Willow Place near Toralemon St., Brooklyn, as part of the Contract 2 Brooklyn Extension and was completed, but not equipped by 1906.
2. Thomas E. Murphy, Electric Power Plants, New York, 1910, pp. 6-8, describes the first alternating current generating installation in Brooklyn completed in 1904: "The Central Power Station of the Brooklyn Rapid Transit Company represents a system of high tension distribution with rotary converter sub-stations, and is a radical departure from the earlier system of operating trolley systems by primary generation of direct current with reliance upon boosters for any long distance." The Manhattan Railway, adopting the sub-station system in 1901, and the IRT in 1904, were therefore quite up-to-date if not pioneering in their choices.
3. Harold C. Passer, The Electrical Manufacturers, Cambridge, Mass., 1953, pp. 276 - ; see also B. G. Lamme, discussion of Bion J. Arnold, "The Electrification of Steam Railroads," Proceedings of the International Electrical Congress, St. Louis, 1904, vol. 3, 269-296. Lamme discusses the development of rotary converters, p. 290.
4. N. Y. Times, 6 June 1901, 8:7; Parsons' Construction Diary, 21 February, 26 February, 1 March 1901; Commissioners' Reports, Proceedings, 1899-1901 pp. 1137-1138, 1142. By the 1930's, with the Independent subway system under construction, underground sub-stations had come to be seen as desirable. See Dexter Boles, "Power System for the Independent Subway of New York City," Municipal Engineers Journal 19 (1933), 124-141; also Behrens, Power Supply, contents of Chapter 7, p. 52, fragment of unidentified work bound in a typescript book, in possession of Mr. Somerville, Power Department, IND Division sub-station, 126 West 53rd Street (hereafter cited as Behrens, typescript, chptr. 7).
5. Several examinations of the sub-stations were made, including an official guided tour of all the original stations, conducted by Constantine Tsirickes and Dominick Cerbone, 24-25 June 1978.
6. L. B. Stillwell, "The Electric Generating Equipment of the New York Rapid Transit Subway," Street Railway Journal (St. Ry. Jl.) 24 (8 October 1904), 619-631; see especially pp. 627-628. An article with information (and often text) identical to Stillwell's is "Underground Rapid Transit in N. Y. City - Part II," E. W. & E. 44 (28 October 1904) 721-729. A note on the numbering of the substations: when originally constructed, they were numbered 1-8; in 1903 when the IRT took control of the Manhattan Railway lines, complete with its own sub-stations, the IRT remembered its own from 11-18.
7. Rapid Transit Subway Construction Company, Contract for Electrical Equipment, 4 October 1901, Agreement between John B. McDonald and Westinghouse Electric and Manufacturing Company, Exhibit 3, Specifications for Rotary Converters, pp. 11-16.

8. From List of Synchronous Converters - IRT Substations, 21 November 1955, Book of Drawings: Substations, Special, Book no. 1, Power Department, IND Division sub-station, 126 West 53rd Street; tour of sub-stations, 24-25 June 1978.
9. Drawing no. 53, "Present and Proposed Sites of Sub-station No. 11," New York, 10 October 1916, Cabinet 34, Drawer 12, Engineer's Record Room, Transit Authority, Jay Street, Brooklyn.
10. Stillwell, "The Electric Generating Equipment...", 625-626.
11. Ibid, 625-626. The cables were subjected to rigorous tests both before and after installation. Also, tour of sub-stations, 24-25 June 1978; Behrens, typescript, chptr. 7, p. 58.
12. A rotary converter picked up current from the transformers' cables via slip rings, as used in an a. c. motor; it passed current to the d. c. bus' cables by means of brushes, as used in a d. c. motor. A converter was therefore a single rotating field, with one side an a. c. motor and one side a d. c. motor.
13. From diagram in plant operators notebook, sub-station 15, West 143rd Street, and from description and free-hand drawing by Dominick Cerbone, tour of sub-stations, 24-25 June 1978. Also Books of Drawings: Substations, Special, Power Department, Sketch no. 1359-2, "A. C. Layout of Sub-Stations," 29 May 1911, revised 10 April 1913; sketch no. I-11541-D1, "A. C. Outgoing Feeder Control, typical wiring," 12 April 1926; sketch no. I-11452-A1, "A. C. Connections, 4000-kw Rotary," sheet no. 2. Consolidated Edison now holds all the tracings of which these books contain xeroxed copies.
14. The tour of the sub-stations gave a decided impression of uniformity, confirmed by subsequent examination of drawings. See in Books of Drawings: Sub-stations, Power Department, Basement Plans, and Rotary and Gallery Floor Plans, for substations 12 (nos. 12642-S, 12640-S, 12641-B), 13 (nos. 12931-B, 12931-S-2), 14 (nos. 12999-B, 12945-S), 15 (nos. 12918-B, 12944-S), 16 (nos. 13004-B, 13003-S), 17 (nos. 12932-S, 13278-S), and 18 (nos. 8883-B, 1122-B).
15. Placement of the transformers and rotaries on the same level was a departure from the practice of the Manhattan Railway Company, which had installed the transformers on a raised gallery extending the lengths of the building. Print Department, Museum of the City of New York, holds an untitled and uncatalogued collection of photographs on the Manhattan Railway electrification, 1899-1901, some of which show sub-station interiors; also Drawing no. 5209, Manhattan Railway Company, tracing in Engineers Record Room, Transit Authority, Jay Street, Brooklyn.
16. Contract for Electrical Equipment, Exhibit 5, Specifications for step-down transformers, p. 18. Although water-cooled

transformers were cheaper to operate than air for the same voltage and rated capacity, it was usually only at main power stations that water was abundantly available for such purposes. Air-cooled transformers were standard for sub-stations. See Samuel Sheldon and Erich Hausmann, Electric Traction and Transmission Engineering, New York, 1911, p. 208.

17. Contract for Electrical Equipment, Exhibit 5, Specifications for Step-down Transformers, p. 18; tour of sub-stations.
18. Contract for Electric Equipment, Equipment 3, Specifications for rotary converters, p. 16; tour of sub-stations.
19. Contract for Electrical Equipment, Exhibit 4, Specifications for motor-generator starting sets, p. 17; tour of sub-stations; Behrens, typescript, chptr. 7, p. 58.
20. Stillwell, "The Electric Generating Equipment...", p. 629. Stillwell notes that the brick compartments also contributed to the safety of the plant operators. H. F. Parshall and H. M. Hobart, Electric Railway Engineering, 1907, cite the IRT system as illustrative of modern practice, and they take special note of the brick compartments, pp. 208, 240.
21. At sub-station #17, Hillside Avenue, Bronx, a bridge over the track originally carried the d. c. feeder cables to the subway right-of-way. In the early 1960's, the bridge was dismantled and the cables placed underground, as at all other sub-stations, (tour of sub-stations).
22. Tour of sub-stations; Dexter Boles, "Power System for the Independent Subway...", Municipal Engineers Journal, p. 137; "The Block Signal and Interlocking Systems of the Subway Division of the Interborough Rapid Transit Company," St. Ry. J. 24 (8 October 1904), 648-656.
23. Sheldon and Hausmann, Electric Traction..., 1911, discusses the advantage of single-level installations, pp. 189-191; tour of sub-stations (included visit to one sub-station, on West 16th Street, built in 1917).
24. Tracings in Cabinet 34, Drawer 12, Engineers Record Room, Transit Authority, Jay Street, Brooklyn, include IRT Co., Extension, Sub-Station No. 12, N. Y., 26 March 1917, among others detailing minor changes to other stations (e. g., offices were added at 96th Street, 1906-1912, and a brick wall and fence enclosed the Hillside Avenue building in 1913).
25. Tour of sub-stations.
26. Tour of sub-stations; the binder holding the Behrens typescript also contains lectures in a study course for Promotion to Electrical Engineer, 1952. Lecture I, p. 5, discusses the policy on the rectifier vs. rotary question.
27. Tour of sub-stations.

Table A. Sub-station Location

Sub-Station	Distance, in miles, from 59th Street Power House *	Distance, in miles, to next further sub-station **
11 122 Park Row (original at 29-33 City Hall Place)	≈ 4.54	≈ 1.89 to no. 12
12 108-110 E. 19th Street	2.78	2.19 to no. 13
13 225-227 W. 53rd Street	.66	2.30 to no. 14
14 264-266 W. 96th Street	2.18	2.37 to no. 15 2.34 to no. 16
15 606-608 W. 143rd Street	4.45	2.73 to no. 17
16 73-77 W. 132nd Street	4.35	3.06 to no. 18
17 129 Hillside Avenue	7.05	≈ 2.50 to end of line
18 1043 Simpson Street, Bronx	7.46	≈ 3.0 to end of line

* From H. F. Parshall and H. M. Hobart, Electric Railway Engineering, New York, 1907, p. 271.

** From Commissioners' Report, 1906, p. 246.

Table B. Rotary Converter Installations, by Sub-station

GE = General Electric
W = Westinghouse

Sub-station	# of 1500-kw units installed by 1906. *	Present Equipment **			
		machine number	manu- facturer	rating in kilowatts	contract date
11	6	1	GE	4000	5/18/16
		2	GE	4000	5/18/16
		3	GE	4000	5/18/16
		4	GE	4000	5/18/16
		5	GE	4000	5/18/16
		6	W	4000	2/28/23
12	5	1	GE	4000	6/ 4/15
		2	W	4000	5/23/16
		3	W	1500	10/ 4/01
		4	W	4000	2/28/23
		5	W	1500	10/ 4/01
		6	W	4000	5/23/16
		7	W	1500	10/ 4/01
13	7	1	W	1500	10/ 4/01
		2	GE	4000	6/ 4/15
		3	W	1500	10/ 4/01
		4 [†]	-	-	-
		5	GE	4000	5/18/16
		6	W	3000	6/14/09
		7	W	3000	6/14/09
		8	W	1500	10/ 4/01
14	7	1	W	3000	9/18/11
		2 [†]	-	-	-
		3	W	1500	10/ 4/01
		4	W	3000	6/14/09
		5	W	3000	6/14/09
		6 [†]	-	-	-
		7	W	1500	10/ 4/01
15	4 ^r	1	W	1500	10/ 4/01
		2	W	1500	10/ 4/01
		3	W	1500	10/ 4/01
		4 [†]	-	-	-
		5 [†]	-	-	-
		6	W	1500	10/ 4/01
		7	W	1500	10/ 4/01 ^r
16	5	out of service - when dismantled, contained only original 1500-kw units.			

Sub-station	# of 1500-kw units installed by 1906. *	Present Equipment **			
		machine number	manu-facturer	rating in kilowatts	contract date
17	4 ^r	1	W	1500	10/ 4/01
		2	W	1500	10/ 4/01
		3 [†]	W	1500	10/ 4/01
		4 [†]	-	-	-
		5	W	1500	10/ 4/01
		6	W	1500	10/ 4/01
		7	W	1500	10/ 4/01 ^r
18	4	1	W	4000	5/23/16
		2 [†]	W	4000	5/23/16
		3 [†]	-	-	-
		4 [†]	-	-	-
		5 [†]	-	-	-
		6	GE	4000	11/19/23
		7	W	1500	10/ 4/01

[†] No rotary converters installed at this foundation.

^r The discrepancy between the number of rotaries installed by 1906 and the total in the original installation is accounted for by the late completion date of these sub-stations. The track which they served, from 145th to 242nd Streets, was completed between 1904-1906, and put in operation after the subway's official opening in October 1904.

* From Commissioners' Report, 1906, p. 246.

** Book of Drawings: Sub-stations, Special, Book no. 1, "Synchronous Converters - IRT Sub-stations," 21 November 1955. Book held at Power Department, Transit Authority, IND Division sub-station, 126 West 53rd Street, New York.

THE RIGHT-OF-WAY: THIRD RAIL AND ROLLING STOCK

John McDonald's contract contained the following specifications for rolling stock: cars were to be numerous enough to provide for at least three-car trains on local tracks at two minute intervals and four-car trains on express tracks at five minute intervals; car construction allowing quick loading and discharge of passengers; attractive appearance, a minimum seating of 48 persons; and thorough ventilation.¹ The contract included no specifications for motive power equipment, since both electricity and compressed air were being considered. The Commissioners later explained that they had purposely set aside decisions on electrical equipment of rolling stock because of the relative youth of electric traction. Rapid technical development characterized the field, and in the Board's opinion, to commit itself too early would preclude the installation of the best and most up-to-date equipment. The contracts for electrical equipment of cars were not let until 1903,² leaving the subway engineers time to evaluate the suitability of different types of equipment for tunnel service.

Two major problems to be solved; a suitable means of current conduction to the car motors had to be developed as did the efficient and safe use of current by the motors. The limited head room in the subway, plus low clearance on curves, also had to be considered. The Commissioners' goal of high capacity and speed with frequent stops, further limited choices. Finally the engineers wanted rolling stock that would not break or wear down easily and that would be virtually fireproof in the event of collision.³

* * *

The limited head room in the tunnels prevented the use of overhead trolleys as current collectors.⁴ Third rail systems were already successfully operating in Chicago, Boston, Brooklyn, and on the Manhattan elevated lines, as well as on interurban roads.⁵ McDonald's electrical consultants urged him in 1900 to adopt the third rail for direct current conduction.⁶

Additional factors influenced the choice of the direct current third rail. The use of alternating current had been briefly considered, but was rejected for two reasons. Work on a. c. motors for traction had been discouraging, and those available in 1900 were relatively untried and less successful than d. c. motors.⁷ In addition, the Manhattan Railway Company adopted the third rail in its 1899-1900 electrification. For the subway directors, the Manhattan system was in this case more than simply a technical model. Adoption of a three-phase a. c. system would have prevented interchangeable operation with the elevated lines, which the subway officials considered particularly desirable. This was primarily a commercial and practical consideration,⁸ the importance of which became evident when the two roads came under joint management in 1903.

In 1901, acknowledging the Boston elevated road as their technical model,⁹ the engineers decided for a third rail. A third rail system adapted to the conditions of subway service was, however, difficult to design. The engineers had to determine how best to arrange the space between the third rail, the rolling stock and fixed structures, so as to allow clearance while efficiently using the limited space in the tunnels. Also needed were a suitable collecting shoe and adequate protection of the 600-volt third rail.¹⁰

Protection of the third rail was a controversial subject. Injuries to workers along the elevated route, directly or indirectly related to the third rail, underscored the need for adequate protection in the cramped tunnels.¹¹ The final decision on protection was made in 1904, late in the subway construction timetable. Parsons, Stillwell and electrical consultant Cary T. Hutchinson considered several methods. Parsons wanted to cut down on the use of wood in the tunnels, and suggested a concrete protection of a crossed-T form, which could serve as a footwalk for workers. Hutchinson supported this proposal. Stillwell favored a wooden covering, which he felt would also form an adequate footwalk.¹² He was impressed with the success of the third rail system of the Wilkesbarre and Hazelton Railway, the first commercially significant installation of a protected third rail. The rail guard was a 2-inch thick pine plank above the rail allowing clearance for an over-running contact shoe.¹³

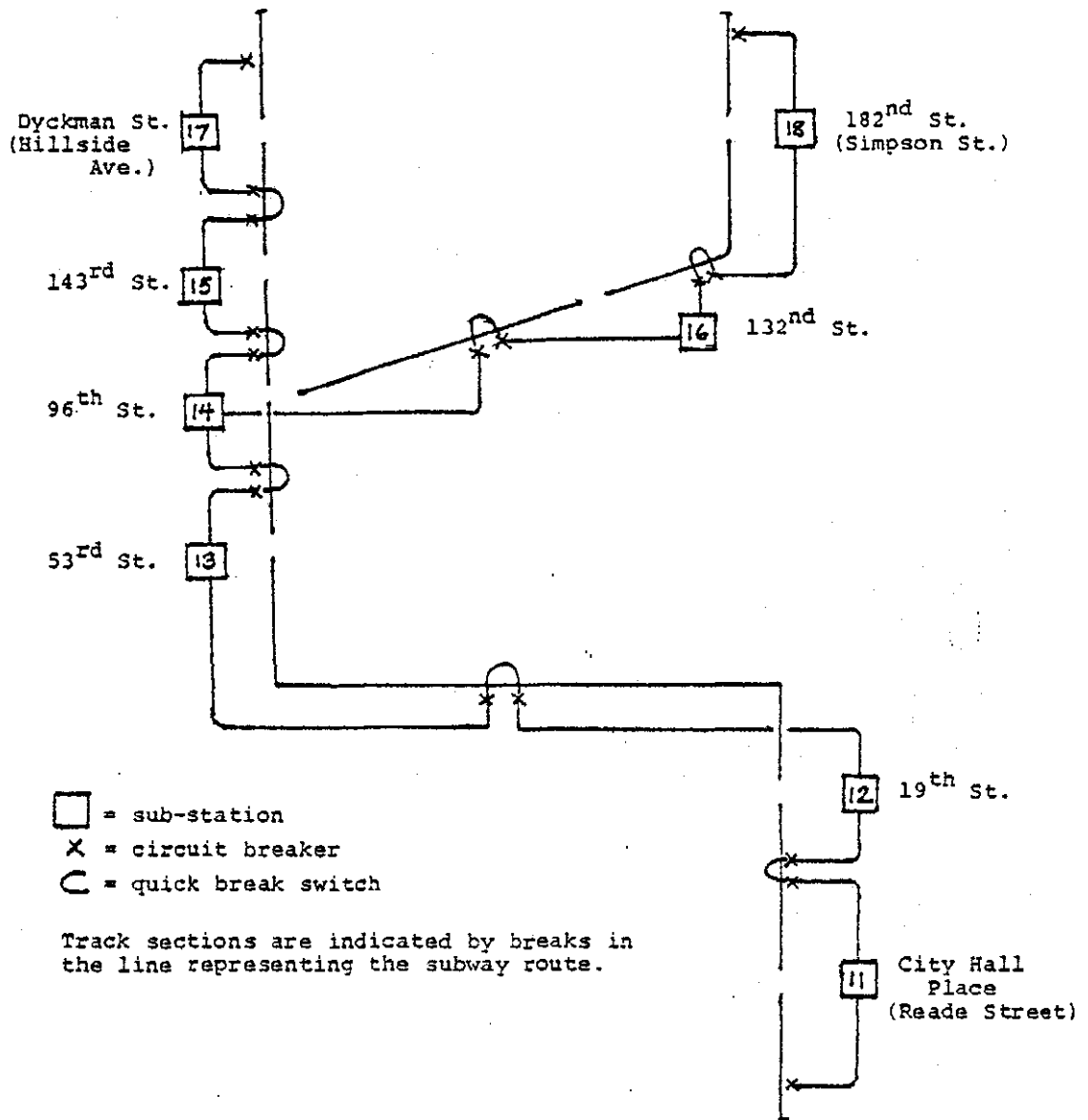
The Interborough ultimately adopted Stillwell's design of a wood plank protection.¹⁴ A 2-inch thick, 10-inch wide plank covered the rail, supported 2 5/8 inches above the rail by a timber beam, running parallel to the rail, to which the protecting plank was bolted. This left open only the side toward the running rails. The horizontal board extended beyond the edge of the rail, making accidental contact with the rail difficult.¹⁵

The third rail itself, of rolled steel 4 5/8 inches high and of equal width at the base, weighed 75 pounds per yard. It contained low percentages of carbon and manganese to increase rail conductivity. Resistance was nonetheless eight times that of an equal section of copper. Granite insulating blocks, spaced nine feet apart, supported the rail, and were cemented to an iron pedestal bolted in turn to the wooden track ties. Copper bonds bridged the joints between the 60-foot lengths of rail. Stillwell chose the Mayer and Englund Company's "protected" bonds, which he had earlier installed on the Manhattan elevated. Four bonds spanned each gap, two riveted on either side, and two on the base, of each rail.¹⁶

A third rail ran along each set of running rails for the length of the subway. Carbon circuit breakers connected the single-conductor, paper-insulated and lead-covered d. c. feeder cables to the rail. Each track breaker was controlled electro-pneumatically from the sub-station supplying it. At the sub-station, lamps indicated the open or closed status of the breaker.

The track section between two sub-stations was divided at mid-distance, each half served by the nearer sub-station. Each station was therefore located at the mid-point of its service area¹⁷ (see Inventory, Diagram B, Schematic of Third Rail Power Supply, by Sub-Station). A flexibly arranged system of emergency switches allowed current to be cut from an entire section of the line in dire emergencies, or from a single track within a section without affecting adjacent tracks, if localized repair work were needed. The switches, located in the ticket booths and conduit manholes along the route, opened circuit breakers at the sub-station terminals of the d. c. feeders.¹⁸

Diagram B. Schematic of Third Rail Power Supply, by Sub-Station*



* Compiled from information in Lewis S. Stillwell, "The Electric Generating Equipment and Power Distribution System of the New York Rapid Transit Subway," St. Ry. J. 24 (8 October 1904),

Current traveled from the third rail to the car equipment by means of over-running contact shoes mounted on the motor trucks. While some railways, including the Manhattan elevated, relied on the weight of the over-running shoe to maintain effective contact with the rail, use of a protected rail demanded a slimmer, lighter shoe to fit between the plank and the conductor. The Interborough hinged the shoe to the truck and used springs to maintain proper downward pressure on the rail. Two slim prongs were made weak relative to the rest of the shoe casting. If the shoe met with an obstruction, it would break at the prongs rather than at the car supports, preventing damage to the car wiring system. Current traveled through the wiring system to the car motors.¹⁹

The choice of motor equipment under the car was determined less by physical constraints of the tunnels than by operating conditions. Although local subway service was to be similar to that of Manhattan elevated in terms of the number and spacing of stations, IRT trains were to be run less often. This demanded a more efficient acceleration, and therefore careful regulation and control of current to the motors.²⁰ The Interborough chose the General Electric - Sprague system of multiple-unit motor control. The system was in use on the Manhattan lines, but the subway installation introduced some innovative modifications.

The introduction of multiple-unit control in 1897 had been crucial to the growth of electric rapid transit system.²¹ (See Electrical Introduction). The system, as defined by its inventor, Frank J. Sprague, involved "a plural control of a plurality of controllers, by which a number of units can be assembled into a train, each unit being absolutely complete without any dependence upon or relation to any other except so far as relates to control of the several main controllers."²²

Each car's equipment included the current collectors, propelling motors, and main controllers directed by the master controller from a single point on the train. Each car unit was equipped to meet only its own requirements. Sprague stressed this aspect, recognizing that the greatest possible car speed between stops was attained by the vehicle with the greatest percentage of its weight directly on its driving wheels. A locomotive represented a concentration of enough power to drag the weight of the cars behind it. With multiple-unit control, all cars of the train had the same characteristics of load capacity, motor equipment, and rate of acceleration. The multiple-unit system enhanced the advantages which the adaptable, high acceleration electric motor brought to rapid transit, surpassing the locomotive in speed and acceleration, and the single motor car in traffic capacity.²³

Both the Westinghouse Company and General Electric produced multiple-unit control systems. The Westinghouse equipment was electro-pneumatic; the power motivating the individual motor control switches was compressed air, regulated by valves in turn operated by electric circuits. The General Electric-Sprague system installed by the Interborough was entirely electrical; the motor switches were operated by a system of circuits and solenoids.²⁴

In the standard G. E. system, the motorman controlled speed and acceleration by varying the current in the solenoids via a complex of parallel-series circuit connections between the train motors and a large resistance, composed of several small resistances which could be cut out of the circuit one by one by contactor switches. After an initial series connection of the two car motors with the car resistance, speed was increased by gradually cutting resistance out of the circuit. With all resistance out, the motors operated in series at full voltage. By switching the two motors to a parallel connection, each in series with a resistance, speed could be further increased by again decreasing the resistance. Highest speed was attained with the motors at full voltage in a parallel connection. Electro-magnets, controlling the switches for each contactor, were in turn activated by one of two small drum controllers placed at either end of the car. A master controller, replaced by the motorman, provided simultaneous control of all the train motors via a continuous low-voltage train-line extending from car to car.²⁵

The system, the standard G. E. type M control, was considered the most advanced of its day when installed on the Manhattan elevated lines in 1900.²⁶ The Interborough installation incorporated improvements over the type M control. An innovative design of the master controller allowed automatic acceleration at a predetermined current while maintaining the option of manual control at lower amperage. If the motorman threw the control handle to the full-voltage position, current-limiting relays prevented excess current from entering the motors at the early stages of acceleration, only gradually allowing greater and greater current to bring the train to full speed.²⁷

Additional changes and improvements included the division of each car's resistances into two groups, each used exclusively with one of the car's two motors. A contactor switch short-circuited only one resistance rather than several. This arrangement allowed larger cross sections of the resistance grids. On the subway cars two or more contactors were mounted on the same base, instead of individually as on the Manhattan installation, saving space and avoiding the need for heavy wires to interconnect to contactors. The G. E. company also considered the subway's contactor short circuit blow-outs more efficient than those it supplied to the elevated, since they combined reduction in weight with a higher current-carrying capacity.²⁸

General Electric and Westinghouse both received contracts for motors. Before selecting specific equipment, Stillwell planned and supervised a series of tests, similar to those done during the elevated electrification. The subway tests, performed in the factories, on the G. E. experimental track in Schenectady and on a half-mile stretch of the Manhattan els, were considered by the Street Railway Journal to be "... the most extensive and exacting that have ever been made in electric railway practice ..." Stillwell's tests were subsumed under 43 headings, and included examination of speed/voltage ratios, heating and cooling curves, insulation, power consumption, controllers, and performance of commutators at different amperages.²⁹

The G. E. and Westinghouse motors ultimately supplied to the Interborough differed slightly in some respects. The G. E. motor, with gear and gear case, weighed 5900 lbs.; the Westinghouse, 5750 lbs. The G. E. gear reduction ratio

was 19 to 63; the Westinghouse, 20 to 63. The G. E. magnet frame was unsplit; the Westinghouse was divided in half. Both, however, were specially designed to meet the rigorous specifications developed by Stillwell (for detailed specifications of motors, see Inventory, List I, Electrical Equipment). The results were high capacity motors (desired speeds of express trains required performance at 325 amps and 570 volts) which could be mounted in the cramped quarters (50 inches from wheel to wheel) under the cars.³⁰ Although the Interborough employed double-truck car mounting, both car motors were installed on a single truck, the other truck being a trailer (see Inventory, List I, for details of truck design). The Interborough used 5-car trains for local service, each with three motor cars and two trailer cars, on which neither truck suspended motors. Express service used 8-car trains, with five motor cars and three trailers. The same motors and gearing were employed for both classes of service.³¹ In this way the Interborough obtained the most flexible use of its motor equipment.

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Beneath every electric car was a maze of air piping and electrical circuits. Severe structural damage to the cars could result in damage to the electrical equipment, short-circuiting, and possibly fire. In a subway it was essential to minimize the risk of fire and smoke. Stillwell was convinced that wiring practice had not kept pace with advances in motor construction and control systems. He claimed that standard wiring in electric cars deteriorated after a few years of service. The design and insulation of the electrical wiring beneath the cars was therefore a key aspect of the company's goal of fire-proof car construction.³²

The Interborough introduced two types of cars into its tunnels during the first year of operation. The original contracts were for composite wood and steel cars. By February 1904, the company had ordered the innovative fire-resistant all-steel cars.³³ The designs of both cars incorporated important structural features and careful insulation of electrical wiring.

The wiring beneath the car included the propulsion circuit, heating and lighting circuits, and the motor control circuits. The first three circuits were self-contained for each car to car. Only the low voltage motor control circuits had a train length component. Also extending the length of the train was the train line pipe for the Westinghouse air brakes, the other multiple-unit system aboard the trains.³⁴

All wiring on the original shipment of composite cars was suspended beneath the cars, outside the main car bodies. The interior flooring was doubled, and enclosed a layer of asbestos rolled felt. A 1/4-inch asbestos board called "transite" sheathed the underside of the pine flooring. Both steel and asbestos separated the motor trucks from the car bodies. The exterior of the steel-framed wood-slat cars was sheathed with copper.

Wire insulation consisted of a layer of paper, succeeded by layers of rubber, weather proofed cotton, and asbestos. Only the heating and lighting circuits entered the car bodies proper; at the forward end of each car the

control circuit wires passed to a switchboard in the motorman's cab. Where wires passed through the car floor, steel chutes lined with asbestos protected the wires from mechanical injury and sealed out dust and dirt. Asbestos-lined boxes enclosed all junctions and fuses and prevented damage to wire insulation from vapors rising from the fuses.³⁵

Louis Duncan and Cary T. Hutchinson, the electrical consultants to the Rapid Transit Commission, reviewed the specifications and drawings for the composite cars early in 1904. They concluded that, due to the care taken with the wiring, the cars were "an improvement upon any car built before." The thorough insulation between the electrical systems and the car body ensured little damage to the latter in the event of an electrical fire beneath the car. However, if during a bad collision the copper sheathing came away from the car, the likelihood of splintering wood making contact with damaged wires rendered the cars as flammable as most others.³⁶

The all-steel cars contained some wood in the door posts, and a small amount was used for the interior finish around the windows. All wood was treated with a fire-proofing compound. The sides were steel sheathed, and the floor was of corrugated iron overlaid with a fire-proof 1½ inch thick board called "monolith", placed directly on the steel under-framing. Asbestos boards also lined the ceiling and sides of the car.³⁷

Because not only the side framing but flooring was of steel, supporting the piping and wires presented new problems. A wood floor would have been strong and workable and allowed flexibility in the support arrangement, but the desirability of completely fire-proof construction precluded this. It was impossible to carry the wires within the car body for the same reason. All standard methods of support involved one of these alternatives. As the innovator in all-steel car construction, the IRT was forced to abandon standard practice in wiring support design.³⁸

The Interborough engineers adopted the practice, used in the interior wiring of buildings, of enclosing the wires in grounded metal conduits, which were either clamped to the steel underframing or passed through openings in the plates and beams of the car support structures.³⁹ The system combined the advantages of durability, strength, low maintenance cost, protection of the wiring from mechanical damage, and immediate grounding of a short circuit. A disadvantage was the increased difficulty of guarding against abrasion of insulation where wires entered or left the pipes. The insulation was the same as on the composite cars. The amount of insulation represented an attempt by the engineers to provide adequate protection while using a minimum of rubber and woven materials which would produce much smoke in case of an electrical fire.

The reduction of insulating materials depended on the design and location of the wiring system. By arranging the contactors in a box at the center of the car, with resistances in two rows on either side, the lengths of the leads, and therefore the amount of insulation minimized. Bus lines from the contact shoes were directly attached to the main propulsion line in enclosed fuses, rather than running the length of the cars. The connections from the propulsion line to the switchboard was also short. Both arrangements further reduced the length of wiring.

The conduits pipes, of the "Loricated" design produced by the Armorite Conduit Company of Pittsburgh, were wrought iron with both interior and exterior surfaces covered with hard enamel. The enamel protected against rust and decreased the chance of abrasion to the insulation as wires were drawn into place. The use of S-shaped and elbow-bent piping lowered the number of times a wire needed to enter or leave a conduit.⁴⁰ Because of the importance of the piping, the Interborough set up a special shop in a repair shed of the elevated division. Workmen prepared templates for the various bends required, and produced a stock of interchangeable parts, greatly easing the installation process and cutting labor cost.⁴¹

On June 1, 1906, two empty trains, composed of all-steel and composite cars, collided on a storage track between 103rd and 110th Street. Although the wood portions of both types burned, filling the tunnels with the smoke, the all-steel cars fared far better than the composite, which were almost completely destroyed. Copper sheathing clearly did not effectively fire-proof the cars.

As a result of the accident, the IRT company decided on steel cars. Loathe to waste its initial investment, however, the company used composite cars with the all-steel cars for several years thereafter. The value of all-steel cars impressed trepreneurs in interurban railroading. The Pennsylvania Railroad had originally provided George Gibbs with the facilities to perfect his designs. (See Rolling Stock discussion in Architectural Report). After the subway accident, W. G. McAdoo, President of the N. Y. and New Jersey Tunnel Company, decided that only all-steel cars would run in his tunnels.⁴² The Interborough innovation in car design proved an important contribution not only to urban rapid transit, but to interurban electric railroading.

Footnotes

1. Contract between Board of Rapid Transit Railroad Commissioners and John McDonald, plus supplementary agreements, 1900, pp.157-158, 172.
2. Commissioners' Report 1906. pp.45-46.
3. "New York's Great Underground Railway," Tramway and Railway World (London) 1904, p.460; also "Steel Cars for the New York Subway," Railroad Gazette 37 (30September 1904), 382-383; "The New Steel Cars for the Subway Division of the New York Interborough Rapid Transit Company," Street Railway Journal 24 (8October 1904), p.634, lists all the conditions which the subway engineers had to consider, p. 634.
4. These conditions helped determine the general design of the rolling stock as well. Double-truck mounting, adopted by the IRT, was characteristic of rapid transit service generally; high carrying capacity required a long car, suspended between two trucks, rather than a short car mounted on a single truck. The tight curves in the tunnel, however, limited car length, and the IRT introduced cars 50 feet 1 inch long, only 3 feet longer than on the elevated and only 3 inches wider. See "Cars for the New York Subway," St. Ry. Jl. 22 (22 August 1903), 204-206. For fuller discussion of general car design, see Architectural Report.
5. Lewis B. Stillwell, "The Electric Power Plant of the Manhattan Railway Company: from the Generators to the Third Rail," St. Ry. Jl. 17 (5 January 1901), 21-47; Lewis B. Stillwell, "Notes on the Equipment of the Wilkesbarre and Hazelton Railway," Transactions of the International Electrical Congress, St. Louis, 1904, vol.3, 340-343; D.W. Young, "The Third Rail on the Baltimore and Ohio," St. Ry. Jl. 21 (14 March 1902), 398-405; N.Y. Times 14 November 1899, 2:3, 4 August 1900, 9:4, 12 September 1901, 10:3.
6. Commissioners' Report (Proceedings) 28 November 1900, p. 1082.
7. Interborough Rapid Transit Company, The New York Subway, N.Y., 1904, p.91. George Westinghouse had valiantly pushed for a viable a.c. traction motor from his Tesla patents, before turning to d.c. traction systems. His company, always a pioneer in alternating current, kept working at it and in 1904 with a successful a.c. system, first installed on the New Haven Railroad the same year, a few years too late for inclusion in the subway planning. See Harold C. Passer, The Electrical Manufacturers, Cambridge, Mass., 1953, pp. 256-258.

8. IRT Company, The New York Subway, p. 91.
9. New York Times, 12 September 1901, 10:3. The Boston road also provided a model for the signaling system; see Signaling, Switching, and Safety section, below.
10. These problems of third rail installations are outlined in D.W. Young, "The Third Rail..."
11. N.Y. Times, 28 August 1903, 14:1. The Manhattan company had faced opposition from New York's Fire Chief Croker, who deemed the high-voltage third rail a danger to firemen using the elevated structure to reach upper-story fires, and therefore a serious fire hazard. The Manhattan directors felt that this opposition was Tammany harassment, part of the bossess' sudden support of the underground project, since no objections were raised a few years earlier when the Brooklyn El's installed a third rail system. See the N.Y. Times, 14 November 1899, 2:3.
12. Parsons' Construction Diary, 24 February 1904, 29 February 1904, 1 March 1904.
13. Stillwell, "Notes on the Equipment of the Wilkesbarre...", p. 343. It is interesting that Stillwell, in a discussion of another engineer's paper, stated that the use of a third rail created serious objections to electric railway service. He favored overhead trolleys where practicable. See "Electric Traction at the International Engineering Congress," Electrical World and Engineer 44 (22 October 1904), 690-691.
14. Commissioners' Report 1904, Report of George S. Rice, Deputy Chief Engineer, p. 163. Unfortunately details of the decision-making were not uncovered. Perhaps Stillwell's evaluation of the Wilkesbarre and Hazelton installation convinced his colleagues; possibly Parsons bowed to Stillwell's electrical expertise. Parsons had indeed earlier considered wood protection, see N.Y. Times, 28 August 1903, 14:1.
15. L.B. Stillwell, "The Electrical Equipment of the New Steel Cars For the New York Subway," St. Ry. J. 25 (4 March 1905), 422-430; third rail discussed, p. 428. See also H.P. Parshall and H.M. Hobart, Electric Railway Engineering, 1907; N.Y. Times, 28 August 1903, 14:1. When first installed the horizontal plank was supported by metal brackets, although the vertical support board was intended from the beginning; see "Completion of the New York Subway," Scientific American 91 (10 September 1904), 178. The Wilkesbarre and Hazelton installation used posts for vertical support, allowing a through-way for the snow and ice which would otherwise have accumulated around the rail. Clearly this was not a problem in the subway tunnels.
16. New York Electrical Handbook, N.Y., 1904, A.I.E.E., p. 296;

also St. Ry. J1. 21 (11 April 1903), 575. The "protected" bonds were of 300,000 circular mils stranded copper with drop forged terminals. A photograph of the bonding is in L.B. Stillwell, "Electric Generating Equipment and Power Distribution System of the New York Subway," St.Ry.J1. 24 (8 October 1904), 619-633, see p. 633.

17. New York Electrical Handbook, p.296; Stillwell, "Electric Generating Equipment....," pp.630-631.
18. "Completion of the New York Subway," Sci.Am. 91 (10 October 1904), 178; Stillwell, "Electric Generating Equipment....," p. 633. Stillwell notes the similarity of the emergency switch installations to the fire alarm boxes of the day. The arrangement allowing cut-off of current to a single track was an improvement over the elevated installation, where all tracks within a section had to be cut off together.
19. Stillwell, "The Electrical Equipment of the New Steel Cars....," pp. 427-428; Samuel Sheldon and Erich Hausmann, Electric Traction and Transmission Engineering, N.Y., 1911, pp. 140-141; Tour of the New York City Transit Museum, Brooklyn, by David Framberger and Barbara A. Kimmelman, July 17, 1978. David Broderick and Co. supplied the contact shoes.
20. "The New Steel Cars for the Subway^{Division}....," St.Ry.J1. 24 (8 October 1904), p.634; "The New York Rapid Transit Subway," St.Ry.J1. 18 (5 January 1901), 425-433, see esp. p.433.
21. Passer, p.275, states that multiple-unit control "gave electricity such an advantage over all other forms of motive power that it soon was recognized as the only motive power suitable for urban rapid transit."
22. Frank J. Sprague, in discussion following Stillwell's "Notes on the Wilkesbarre....," pp. 378-379; Frank J. Sprague, "Digging in the Mines of the Motors," Electrical Engineering 53 (1934), 695-706. Sprague's invention was the result of the adaptation of his system of external control of electric elevator motors to car motor control.
23. Frank J. Sprague, "The Multiple Unit System for Electric Railways," Cassier's Magazine 16 (August 1899), 439-460; "Maximum Average Speed and Capacity of Rapid Transit Trains," Railroad Gazette (20 January 1893), 51-53. The latter article compared steam and electric traction, noting that the electric motor's greater acceleration gave a higher average speed than steam with the same maximum speed, and was therefore more power-efficient.
24. Henry H. Norris, Electric Railways, Chicago, 1913, pp. 51-52, 65. Norris gives a detailed description of the Westinghouse system, p. 71. Sheldon and Hausmann, pp.104-106, give a good

description of both electropneumatic and electric systems. The discussion here will concentrate on the G.E. system.

25. Sheldon and Hausmann, pp. 74-75; "Underground Rapid Transit in New York City- III," Electrical World and Engineer 44 (5 November 190-), 759-760, The drum controller also operated a reverser switch, allowing the motorman to reverse current direction in the motors if desired.
26. "Recent Developments in the Traction Field," St.Ry.Jl. 18 (5 October 1901), 489-494; see also "The Rolling Stock of the Manhattan Railway Company," St.Ry.Jl. 20 (6 December 1902), 907-914.
27. "The Type of Controllers and Motors to be Used in the New York Subway," St.Ry.Jl. 21 (14 March 1903), 412-415.
28. Ibid. Since the motor construction of both companies was almost identical (see Inventory, List I), the awarding of two contracts may have had "political" motivation, or possibly represented an effort to stimulate competition between the large manufacturers.
29. Ibid. The tests are described in detail on pp. 447-448.
30. "The Type of Controllers....," p. 446; "Westinghouse Motors for the Rapid Transit Subway," St.Ry.Jl. 21 (21 March 1903), 442-444; "Underground Rapid Transit in N.Y.C.-III," E.W. and E., p.759; "New York's Great Underground Railway," Tram. and Ry. Wrld., p. 460. G.E.'s motor had a high self-inductance, which prevented flashing over. The "Westinghouse..." article does not indicate if this was feature of the Westinghouse design.
31. "Westinghouse Motors....," p.442; Tour of N.Y.C. Transit Museum.
32. L.B. Stillwell, "The Electrical Equipment of the New Steel Cars....," pp.422-430, see especially p. 422.
33. "Fireproof Cars for the New York Subway," American Engineer and Railroad Journal 78 (March 1904), 106-107; Contract for Interchangeable Steel Passengers Cars, between the IRT and the American Car and Foundry Co., October 1904,
34. This aspect of the multiple-unit control system, with each car's equipment responsible for only its own propulsion and third rail auxiliary systems, was stressed by Sprague, "The Multiple Unit System....," Cassier's 16 (August 1899), 439-460; "Airbrakes for the New York Subway," St.Ry.Jl. 21 (31 January 1903), 200; N.Y. Times, 16 September 1903, 7:4. The control apparatus for the air brakes, supplied by the Christensen Engineering Company, was standard for elevated railways, (they had been installed on the Boston and Brooklyn els) and on high-speed interurban lines.
35. Commissioners' Report, 1904, Consulting Electrical Engineers'

Report, pp. 153-154; Chief Engineer's Report to the Commission, dated 1 January 1905, quoted in the Chamber of Commerce of the State of New York, Report on Rapid Transit, 1905, pp. 148-149; "The New Steel Cars for the Subway Division...", St. Ry. Jl. 24 (8 October 1904), pp. 636-637; "N.Y. Subway Cars, " Amer. Engr. and RR. Jl. 77 (March 1903), 95-96; "Cars for the New York Subway, " St. Ry. Jl. 22 (22 August 1903), 265-266.

36. Commissioners' Report 1904, Consulting Electrical Engineers' Report, pp. 153-154; "Steel Cars for the New York Subway, " R.R. Gazette 37 (30 September 1904), 382-386, especially p. 382.
37. "The new Steel Cars for the Subway Division...", St. Ry. Jl. 24 (8 October 1904), 643-645; "Steel Cars...", R.R. Gaz., pp. 385-386.
38. Stillwell, "The Electrical Equipment of the New Steel Cars...", pp. 422-430. The following account of the steel car wiring is taken from this article, which describes the system in great detail. Only the more important features will be discussed here:
39. Stillwell, "The Electrical Equipment of the New Steel Cars...", p. 423, writes that this practice "had been used before in some cases."
40. Ibid, p. 424.
41. Ibid. Stillwell describes the shop in detail, pp. 428-429.
42. N.Y. Times, 3 June 1906, 22:5. A similar accident a year earlier, with the same results, is described in the Amer. Engr. and R.R. Jl. 79 (May 1905), 169. It is noteworthy that in 1907, the N.Y. Herald complained that the ratio of steel to composite cars, 300 to 791, was still far too low; see N.Y. Herald 21 August 1907.

To be added to Inventory, List I, "Equipment..."

Rolling Stock

General Electric Motors: type 69, 200-hp. capacity; magnet frame unsplit; fixed coils wound with flat copper ribbon, insulated with mica and a specially prepared fire-proof and water-proof fabric; armature, series slotted drum barrel winding, copper bar conductors separately insulated, core of iron-clad type; commutator segments of hard drawn copper; gears of high grade cast steel, pinion of forged steel; gear case bolted directly to motor frame (this feature first introduced on Manhattan elevated installation); mounting, nose suspension.

Westinghouse Motors: no. 86, similar to Westinghouse "50-C" motor, 200-hp. capacity; magnet frame of cast steel split in two; field coils of copper strands wound on edge, insulated with mica and asbestos; armature, 20 inches in diameter, 1930 lbs., slotted drum type, of sheet steel and cast iron, insulated by mica; commutator segments of rolled and hard drawn copper; gears of solid cast steel with cut teeth, pinion of forged steel with cut teeth; gear case of malleable iron.

Trucks: built by the Baldwin Locomotive Works, Phila., to designs and specifications of Engineers Gibbs and Thompson, Interborough Rapid Transit Company, embracing the Motor Car Builders Standards, incorporating latest in both steam and electric railway practice; special design of truck bolster and spring plank created space necessary for motors; motor trucks arranged for nose suspension; wheels and axles from Standard Steel works, wheels with 5 5/8 inch steel tires; height of both motor trucks and trailer trucks 30 inches, wheel base of motor trucks 6 feet, 8 inches, of trailer truck 5 feet 6 inches; diameter of motor truck axle at center 6 1/2 inches, at wheel seat 7 3/4 inches, trailer axle diameter at center 4 3/4 inches, at wheel seat 5 3/4 inches.

Air Brakes: Westinghouse Air Brake Company provided piping, valves, brake cylinders; shoes of "Diamond S" type supplied by American Brake Shoe and Foundry Company; Christensen Engineering Company, Mil., provided air compressors, of Christensen No. 2 independent type, motor driven, and Christensen automatic multiple unit governor.

Cab Equipment (Steel Cars): master controller and energizing switch, circuit breaker resetting switch, marker, cab heater switch.

Vestibule multiple-unit control cut-out switch, main
Switchboard: motor/trolley connecting switch, lighting, heating
(Steel Cars) air compressor and governor apparatus.

Compiled from "The Type of Controllers and Motors to be used on the New York Subway," St. Ry. Jl. 21 (14 March 1903), 412-415, and "Westinghouse Motors for the Rapid Transit Subway," St. Ry. Jl. 21 (21 March 1903), 442-444; "The New Steel Cars for the Subway Division of the New York Interborough Rapid Transit Company," St. Ry. Jl. 24 (8 October 1904), 642-643 (contains more detailed specifications than given above); "Air Brakes for the New York Subway," St. Ry. Jl. 21 (31 January 1903), 200.

SIGNALING, SWITCHING, AND SAFETY

The safe and efficient control of train movement greatly concerned the designers of the IRT. Subway engineers planned and built express tracks, alongside and parallel to the local tracks, to accommodate the high speed service. At the express stations, at the 96th Street division into the uptown east and west side lines, and at the City Hall station, complex track arrangements demanded proper coordination of train movements. High speeds, frequent service, and complex tracks layouts required a reliable system of automatic signaling and switching.¹

Street railways were not models for the subway signal system. High speed was not a condition of street-level service, whatever the motive power, and the cars were directed by the traffic regulations and conditions of all street traffic. No independent signal system was necessary.

The subway engineers thus turned elsewhere. The system ultimately installed was described by contemporaries as using "old and well-tried methods" and also applying "some entirely new principles . . ."² The mystery combined innovative design with techniques and practices drawn from various classes of high speed railway service.

Steam railroad practice served as the general model for electric railway signaling systems. The conditions of subway service were identical to those on steam railroad trunk lines. An author in the Railroad Gazette noted that "train service on express tracks will be similar to that on steam roads in that the trains will run at speeds of from 35-45 miles an hour . . . making no stops for long distances."³ Similar conditions of service resulted in the adoption of similar methods of traffic control.

In 1900 heavy traffic on the interurban railroads was something new.⁴ English railroads handled a high rate of traffic much earlier; accordingly block signaling was introduced there in 1841.⁵ Block signaling is the division of the length of the track into blocks or sections; a signal at the entrance to each section indicates the presence or absence of a train within that section. Block signaling technology quickly developed from semaphore signal arms, hand-operated from the engine cab or by a signal man in communication via telegraph with the farther end of the block, to various methods of powered operation. Hydraulic power, water power, glycerine, or alcohol was standard for these systems.

American railroads began to adopt block signaling in the 1870's, improving on British practice by having the arm dropped rather than raised to the horizontal danger position. In this way a failure in the signal system would put all signals at danger, decreasing the likelihood of collisions. But because American roads had less traffic than the British, because hydraulic systems were unreliable, and legislatures hesitated to impose controls on private railroads, the adoption of block signaling in the United States was limited.⁶

American automatic block signaling received a boost when in 1881 George Westinghouse formed the Union Switch and Signal Company. Westinghouse applied his experience with the air brake to the development of electro-pneumatic automatic signal. A low voltage d. c. track circuit operated the valves of a compressed air system, which in turn controlled the position of the signal. Electricity traveled by wire to one rail at the head of the block, then down the track to the signal end, where the current crossed to the other rail through the relays of the signal circuit, and returned to the head of the block. Each section of track was electrically insulated from the adjoining blocks. When a train entered the block, the current short-circuited the system by crossing the track through the car wheels and axles, and never reached the signal relays. As the last car left the block, the track circuit was again closed. The opening and closing of the signal relay switch activated electric circuits controlling the valves of the pneumatic circuit.⁷

In 1884, Westinghouse installed his electro-pneumatic signals on a stretch of the Pennsylvania Railroad east of Pittsburgh. Traffic volume on the steam roads increased, and by 1890, recognition of the need for automatic signaling under such conditions spurred wider adoption of the electro-pneumatic system in the United States.⁸ The timing of its introduction and development meant that the system was no long experimental. It was thoroughly up-to-date when construction crews broke ground for the New York subway in 1900.

Electro-pneumatic operation of signals was ideally for the subway. The compressors and dynamos could be located far from the cramped tunnels. The conducting wires and small pipes took up little space along the tunnel roof, and the signal apparatus was quite compact.⁹ These considerations, plus its record of reliable service, prompted the adoption of the Westinghouse electro-pneumatic block signal system, whose "essentials (had been) worked out with years of practice in steam railways."¹⁰

The modifications of signal technology were of course required in changing from steam to electric railway service. On steam roads the rails could be devoted entirely to the signal circuit, while on most electric railways the running rails returned the propulsion current to the station. Use of the same track for both propulsion and signal circuits complicated the operation of each. First, electric block signaling required that at least one rail be divided into electrically insulated sections, sacrificing its usefulness as a propulsion current return. In order to return the entire propulsion current along the remaining undivided rail, its electrical resistance was effectively doubled, decreasing the efficiency of power return.¹¹

More important for safety was the severe voltage drop in the propulsion current along given sections of track during periods of heavy traffic. Experience on steam roads had shown that even small stray currents could interfere with the proper functioning of the signals. Clearly, reliable

automatic block signaling on electric railways required a signal circuit control which would not be influenced or damaged by the power surges and drops of the higher voltage propulsion return current. For many years these difficulties prevented the introduction of automatic electric signaling on electric roads.

The first and only major installation of electric block signaling on an electric road in the United States prior to the New York subway was on the Boston Elevated lines in 1900-1901.¹² The company installed a modification of the Westinghouse electro-pneumatic system, designed by S. M. Young for the Pneumatic Signal Company.¹³ The Young system was the first to subdivide only one rail into insulated blocks, leaving the other to return the entire propulsion current. The elevated structure had a large return capacity, somewhat relieving the burden on the individual rail and obviating one of the objections to the use of the same track for both propulsion and signal circuits. In addition, block length was short, lessening the likelihood of very great voltage drop along a given section. This alone, however, was not sufficient protection against interference by the propulsion current.

The Boston installation solved this technical problem by opposing the directions of the propulsion and signal current through the rails. The signal relays were provided with polarized armatures, sensitive only to direct current flowing in a single direction. The higher voltage propulsion return current, flowing in the opposite direction, would be ignored by the relays, preventing its damaging and dangerous intrusion into the relay and signal mechanisms.¹⁴

The service of the Boston elevated system was in many ways analogous to the service planned for the New York subway (see Electrical Introduction). In July 1902, supervising and electrical engineers of the Rapid Transit Subway inspected the Boston system. Also present was a representative of the Union Switch and Signal Company, the eventual recipient of the Interborough signal contract.¹⁵ Boston provided the only example of automatic block signaling with a track circuit on an electric road, and the subway engineers felt that its system successfully handled the moderately heavy traffic on the els.¹⁶

Traffic conditions in New York were expected to be of "unprecedented density," requiring a propulsion current of great magnitude.¹⁷ Interborough engineers feared that the correspondingly great current fluctuations which even normal service might induce would damage the signal circuit controls of even the Boston system.¹⁸ They sought to design a system in which the signal circuit used current entirely different from the propulsion current.

Alternating current provided the answer. Union Switch and Signal engineers, working with George Gibbs and J. M. Waldron of the Interborough, replaced the polarized direct current relays of the Boston system with relays sensitive only to alternating currents. The fluctuating magnetic

field of the alternating current flowing through the rail induced a second current in a relay coil placed near, but not in contact with, the original current. The steady magnetic field of the direct current, unable to induce currents in nearby conductors, could not affect the relay mechanism. The relays, selectively transmitting the low voltage alternating signal current, remained unaffected by the behavior of the direct current propulsion return. Interposition of a shunting choke coil at the signal relay further screened the direct current from the signal mechanism. Aside from these subtle modifications, the system was identical to the Boston elevated adaptation of the Westinghouse electro-pneumatic operation.¹⁹

The New York subway signal system was both innovative and pioneering. It interested major trunk line electric roads in the New York area. Although many electric railways were hesitant to install electric block signaling, the use of alternating current for signal systems on direct current roads eventually became standard practice.²⁰

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The Interborough Company installed the automatic block signaling along the entire length of the express tracks, and on local tracks at station approaches and points of low visibility. The design and equipment of the subway signal installation incorporated numerous features enhancing safe, sure control of traffic. From each of seven substations, a motor-generator unit provided 500-volt alternating current for transmission along feeder cables to mains mounted along the tunnel roof at the tops of the columns. Four of the seven could supply current sufficient to operate the signals, providing a safety for the system in case of difficulties at a particular substation. A step-down transformer mounted on the signal post at the entrance to each block tapped the a. c. mains, and contained two secondary coils. One, carrying 10-volt current, connected across the track rails. The second provided 50-volt current to the signal lamps. Because of the dim light and cramped quarters in the tunnel, the company used transparent colored glass discs, backed by two electric bulbs to ensure continuous lighting, rather than the standard semaphore arms. Smaller semaphore arms gave a position signal in case the lighting system should fail. Both home and distant signals were provided, so that a motorman knew the status not only of the block he was approaching but also the one beyond it.²¹

Alternating current was used exclusively for lighting the signals and operating the track relay. Within the signal mechanism itself, the circuits operating the valves of the pneumatic system used 16-volt direct current. Sets of batteries located in signal towers along the route supplied the signal mechanism. All the primary and auxiliary signal circuits were completely independent of the propulsion and tunnel lighting circuits. Failure of one system would not incapacitate the others.

The basement of seven of the eight substations, an Ingersoll-Sergeant air compressor supplied the power for the pneumatic control of the colored signal discs (see photo 17-H). Each compressor fed the 2-inch pipe extending the length of the subway, mounted on the columns near the a. c. mains. Three of the compressors were in regular service, the others were kept in reserve. The compressors were controlled automatically by the air pressure in the system.²² These features insured air pressure sufficient for signal operation.

The Interborough engineers thought that the automatic block signal would operate best by adopting overlaps. An overlap system extended the length of a block circuit a certain distance beyond the signal post of the following block. Extensive tests and studies by both the Interborough and Pennsylvania Railroad engineers provided train speed curves and braking curves, used to determine an appropriate overlap distance. Block lengths were set at twice that of the overlap, giving a shorter block length than was standard. This was desirable in the subway because the shorter the block, the greater the carrying capacity of the road.

Without an overlap a train cleared the signal of the block behind it as the last car left the block, and set the signal of its new block at danger. If it stopped just a few feet inside this block, a fast train overrunning the danger signal could not avoid a collision. With an overlap, a train leaving a block would not clear the signal until the last car had passed beyond the end of the overlap. An adequate braking distance would then exist between the danger signal and the end of the lead train.²³

An automatic train stop, a device originally introduced on steam roads,²⁴ enhanced the effectiveness of the overlap system. Beside the third rail at the entrance to each block was an automatic trip, controlled electro-pneumatically by means of the same mechanism used to operate the signals. The movement of the home signal to danger triggered the valve circuits of the automatic trip, and moved it into an upright position. On the truck of each subway car a similar trip, connected with the mainline of the train's air brake system, extended downward toward the track. If a train passed the danger signal, the upright track-level trip hitting the trip on the truck opened the main air pipe and applied the brakes throughout the train. Because of the overlap system, the danger signal and automatic trip was set by a train at least $1\frac{1}{2}$ blocks ahead of the signal, leaving enough space for the brakes to stop the train before collision.²⁵

Electro-pneumatic interlocking switching and signaling, also provided up the Union Switch and Signal Company, protected track junctions all along the route. Through the intervention of electric circuits, a single control operated an entire set of interlocked signals and switched to produce a particular track pattern. The protection was particularly important at the route terminals and train yards. At the City Hall station and at the 137th Street underground storage yard, trains moved through the murky dimness of the tunnel; at the main yards at 149th Street and Lenox Avenue a maze of track with complex junctions led to car barns, and repair, machine,

and paint shops (see photo A). The interlocking installation facilitated safe and efficient coordination of traffic through these areas.

Interlocking control machines were placed at selected stations on the route. An interlocking tower at City Hall, compactly built to fit cramped tunnel conditions, accommodated three machines and an operator (see photo B). Machines stood unenclosed in some of the other stations. The number of control levers at each installation ranged from six or seven at local stations to twenty or thirty at City Hall, the Lenox Yards, and other complex locations. The interlocked switches totalled 224, and all signals, both blocked and interlocked, totaled 691.²⁶

George Gibbs and his staff incorporated numerous other safety features along the right-of-way and on the trains themselves. A train could not move forward without pressure by the motorman on a "dead-man's button." If he eased the pressure due to inattention or accident the train would come to a stop. An alarm system existed not only aboard each train but in the tunnels and stations, allowing trainmen and station attendants to signal the generating and sub-stations to cut power to a given section of track in case of emergency. Station attendants could also set at danger all signals on approaching tracks, keeping trains out of an emergency area.²⁷

Several weeks before the subway officially opened, practice trains began rumbling through the tunnels, giving motormen a chance to familiarize themselves with the route. Company engineers were also able to satisfy themselves concerning the proper operation of the signal installation. In 1906, after eighteen months of operation, signal engineer J. M. Waldron expressed his satisfaction with the block signal system. He determined the number of a. c. relay failures at 17 a month, or approximately one in every 75,000,000 movements of the signal apparatus. Forty percent of these resulted from slivers from the brake shoe bridging the insulation between blocks, rather than any failure in the signal mechanism. He also noted that in all cases of failure, trains were detained when they might have proceeded, and never cleared when they should have been stopped.²⁸

The major safety and traffic control installations on the New York subway - the automatic block signaling, interlocking switching and signaling, and the automatic train stop - had been for years standard equipment on trunk line steam roads. An innovative adaptation of the Westinghouse electro-pneumatic system allowed the introduction of track circuit signal control on electric railways. The success of the subway installation hastened the system's adoption by the larger electric roads. The Interborough served the important role of intermediary in a transfer of technique and practice between two types of heavy railroad service.

Footnotes

1. Board of Rapid Transit Commissioners, Contract for Subway Construction with John B. McDonald, section on Signaling. The 1899 contract stipulated that "signalling devices are to be of the most approved and reliable character ... preference being given to a system which will automatically bring a train to a stop in the event of a man in charge failing to obey a signal." Safety was clearly a major consideration. The technical journals which described the signal system also recognized that the frequent high speed service was the condition demanding the signaling system: see "The Signal System on the Subway Division, Interborough Rapid Transit Company, New York," Engineering Record (E. R.) 50 (12 November 1904) 568-570; also "The Completion of the New York Subway," Scientific American 91 (10 September 1904), 178.
2. "Signals in the Subway," Railroad Gazette (R.R. Gaz.) 37 (7 October 1904), 410-414, quote p. 410.
3. "Signaling in the Subway," R. R. Gaz. 37 (16 September 1904), 343-344.
4. B. B. Adams, "Railroad Signals, Block and Interlocking Signals," Scientific American 87 (13 December 1902), 404-408, notes that only since 1890 had traffic conditions increased to the point that block signaling was considered desirable.
5. Charles Hassel, Member A. S. C. E., "The Evolution of Railroad Signaling," (in form of letter to editors), R. R. Gaz. 35 (18 July 1907), 503-504. Hassel writes that Sir Charles H. Gregory introduced the semaphore signal, in 1841, intending it "to closely imitate the action of a man moving his arms through a vertical arc." The brief account of block signal development which follows is from this article.
6. Ibid. Continental practice followed the American, rather than the British, practice of raising the arm for the clear signal.
7. Harold C. Passer, The Electrical Manufacturers, Cambridge, Mass. 1953, pp. 129-130; the operation of the electro-pneumatic system is described in "The Completion of the New York Subway," Scientific American 91 (10 September 1904), 178.
8. "American Practice in Block Signaling - IV," R. R. Gaz. 22 (6 June 1890), 392-394. This article refers to its use as standard practice by 1890; Adams, "Railroad Signals...", Scientific American 87 (13 December 1902), 404-408, also notes that changes in traffic conditions necessitated adoption of block signals "to space fast trains."
9. "The Signal System on the Subway Division...", E. R. 50 (12 November 1904), p. 568.

10. Ibid, p. 568.
11. "Automatic Block Signaling on the Boston Elevated," R. R. Gaz. 33 (11 October 1901), 692-694.
12. R. R. Gaz. (3 March 1893), 66, notes that the first electrically-operated automatic block signals in England were installed in 1893 on the Liverpool Overhead Railway, an electric road. I unfortunately do not know the technical details of the system; it is possible that in this case, the propulsion current was returned by a wire or rail independent of the running rail (this was an occasional, though not standard, practice), surrendering the entire track for the signal circuit.
13. "The 'Young System' of Automatic Block Signals," R. R. Gaz. 35 (25 December 1903), 925. Although "Automatic Block Signaling on the Boston Elevated," R. R. Gaz. 33 (11 October 1901), p. 692, states that the Union Switch and Signal Company made the installation, the system described is identical to the Young system. Two possibilities are suggested; that the Union Switch and Signal Company, which did install the interlocking switches for the road, began commercial installation of the Young system itself, or that the author of the second article assumed the same company had made both the signal and interlocking installations.
14. "Instructing Trainmen on the Boston Elevated," R. R. Gaz. 33 (19 April 1901), 269. The following articles describe in detail the Boston installation: "Automatic Block Signaling on the Boston Elevated," R. R. Gaz. 33 (11 October 1901), 692-694; Howard S. Knowlton, "Train Movement Signaling on the Boston Elevated Railway," St. Ry. Jl. 18 (7 September 1901), 259-263.
15. Parsons' Construction Diary, 7 July 1902. The actual contractor for signals and interlocking switches were not let until 1903 (Railway Age 36 (23 October 1903), 567).
16. "The Signal System on the Subway Division...", E. R. 50 (12 November 1904), p. 568.
17. Ibid, p. 568.
18. "Signals in the Subway," R. R. Gaz. 37 (7 October 1904), 410-411.
19. Articles from which the above account is drawn: J. M. Waldron, "Signals in the New York Subway," Digest of the Proceedings of the Railway Signal Association 1895-1905, vol. 3, 236-240; "The Signal System on the Subway Division...", E. R. 50 (12 November 1904), 568-570; "Signaling in the Subway," R. R. Gaz. 37 (16 September 1904), 343-344. The Union Switch and Signal Company had earlier in 1904 made a small trial installation of the a. c. system on the North Shore Railroad in California, which was quite successful.

The Interborough installation was the first extensive use of the system on a major road.

20. "Inspection of the N. Y. Subway by Pennsylvania Railroad Officials," St. Ry. Jl. 24 (22 October 1904), 773; "Block and Interlocking Signals in the Electrical Zone of the N. Y. Central and Hudson River Railroad," Engineering News 55 (14 June 1906), 648-650; Henry H. Norris, Electric Railways, New York 1913, 226-227, discusses the use of this system on electric railways a decade after its introduction.
21. A distant signal indicated the state of the home signal of the block beyond it.
22. "The Block Signal and Interlocking Systems of the Subway Division of the Interborough Rapid Transit Company," St. Ry. Jl. 24 (8 October 1904), 648-656; "Signals on the Interborough Rapid Transit Lines in New York City," Railway Age (17 June 1904), 1108-1117; "Signals in the Subways," R. R. Gaz. 37, p. 411. These articles describe in great detail the entire block signaling and interlocking systems, and provide more information on the actual mechanical and electrical mechanisms than is provided here. The articles also contain helpful photographs and illustrations of the equipment.
23. "The Block Signal and Interlocking Systems...", St. Ry. Jl. 24, describes the design of the overlap system, pp. 649-651, and provides diagrams illustrating the installation. See also "The Signal System...", E. R. 50, p. 568.
24. The automatic train stop used on the subway was designed by F. E. Kinsman for use on steam roads. Plainfield, N. J. Press, 28 October 1904, Belmont Scrapbook, Museum of the City of New York.
25. "Signals in the Subway...", R. R. Gaz. 37, p. 411; "The Block Signal and Interlocking Systems...", St. Ry. Jl. 24, pp. 654-655.
26. "The Signal System...", E. R. 50, p. 570 lists all the interlocking plants along the system. The signal tower has since been removed from the City Hall station which is no longer in use.
27. "The Block Signal and Interlocking Systems...", St. Ry. Jl. 24, 655; "The Signal System...", E. R. 50, p. 569.
28. St. Ry. Jl. 24 (22 October 1904), 771; J. M. Waldron, "Alternating Current Track Circuits in the N. Y. Subway," R. R. Gaz. 40 (11 May 1906), 472-473. Bion J. Arnold in 1907 did a series of studies on various aspects of subway service, including the signal system, offering criticism and recommendation. I do not know if the Interborough pursued these studies further. See Bion J. Arnold, Reports on the Interborough Rapid Transit Company of New York, to the Public Service Commission, First District, Nos. 1-7, 1907-1908.

HISTORIC AMERICAN ENGINEERING RECORD
INTERBOROUGH RAPID TRANSIT SUBWAY (ORIGINAL LINE)

NY-122

"ARCHITECTURAL DESIGNS FOR NEW YORK'S FIRST SUBWAY"

Location:	New York City, New York UTM: (Indeterminable) Quad: Brooklyn, Central Park
Date of Construction:	1900-1904
Present Owner:	City of New York
Significance:	The IRT was New York City's first subway..
Historian:	David J. Framberger, 1978.

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Although the IRT was primarily an engineering feat, architecture and interior design were important to the completion of the subway. The architectural elements of the original IRT subway included underground stations, elevated stations, ornamental control houses, kiosks, the main power house, eight power sub-stations, and rolling stock.

The architecture of the subway can be classified generally as 20th-century traditional--that is, architecture that "derives its sanctions from the traditions of the further past." [1] The use of the word traditional here refers to the vocabulary of ornamental motifs that were applied to subway construction. Although traditional, the architectural elements exhibit both an academic and a stylized approach to design. In addition, the subway system reflects the intellectual and artistic temperament of the turn-of-the-century era and, most importantly, makes clear the working relationship of the architect and the engineer.

References to the artistic treatment of the subway were rare during the early deliberations of the Board of Rapid Transit Railroad Commissioners, most likely because the more pressing technological and financial issues were still undetermined. The Rapid Transit Commission Report of 1891 does, however, state that every effort should be made "in the way of painting and decoration to give brightness and cheerfulness to the general effect" of the stations. [2] An actual architectural plan was mandated by the 1894 Rapid Transit Commission and the engineers produced a small neo-classical station house to be erected near City Hall. Another intention was expressed in the original contract of 1899, which specified white or light-colored tiles or enameled brick for the station walls, except where color was to be "introduced for architectural effect." [3] These brief comments indicate that the Board had some form of architectural treatment, however vague, in mind from the very beginning.

Chief Engineer William Barclay Parsons was also concerned with various aesthetic possibilities, some of which he discussed in his 1894 report on European transit systems. [4] The London Metropolitan Railway was among the systems studied, and Parsons noted that,

"No attempt was made to give the stations a pleasing appearance; in fact, any attempt would have been rendered ineffectual by the engine smoke and the hideous advertising signs with which the station walls in England are covered."
[5]

He was, however, impressed by the generous size of the station platforms and stairways. In Berlin, Parsons inspected the Stadtbahn,

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opened in 1882, and commented on two stations of this elevated railway. The stations were enclosed by an iron and glass shed, reminiscent, though on a smaller scale, of the great train sheds built throughout the western world during the Victorian period. The relation between form and function in these stations was obscured, however, by their embellishment with elaborate neo-baroque ornamentation. Of the stations of the Chemin De Fer De Sceaux in Paris, Parsons had this to say:

"All of these stations have been designed with great skill with a view to make them pleasing and attractive in appearance, and to afford the maximum of convenience to the passengers. The architectural treatment consists in the avoiding of flat barren walls, by furnishing them, where not roofed, with a fine cornice and ornamental railing, and where in tunnel, by dividing them into panels by means of pilasters with a cornice and molded base. These panels are covered with porcelain tiles, and the small arches in the station roofs are made with bricks of the same material. Porcelain was used instead of enameled brick, as it was feared the polished surface of the latter might be thrown off by frost. To facilitate the movement of passengers there are two separate stairways to each platform, one for incoming and the other for outgoing passengers." [6]

Here it is obvious that Parsons was impressed by logical design, an efficient traffic flow, and a conservative decorative scheme that avoided both the Baroque extravagance of the Stadtbahn and the blandness of the Metropolitan.

When Chief Engineer Parsons made his trip abroad in 1894, he saw only a small sample of underground transit systems compared to what he would have seen had he traveled five years later. For in the late 1890s and early 1900s, many existing European transit systems were extended and several new ones begun. The role of the artist and architect became increasingly important in these new systems, and their potential influence on the New York subway was great.

European designers of the 1890s were experimenting with "a short but very significant fashion in decoration" [7]--Art Nouveau. Introduced in the 1880s by designers and book illustrators, the flowing foliate designs of Art Nouveau were first applied to

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architecture, independently it seems, by the American Louis Sullivan and the Belgian Victor Horta. But while Sullivan's Nouveau ornament remained basically a personal eccentricity, the Nouveau of Horta quickly became high fashion on the Continent.

Art Nouveau and its complementary movement in Germany and Austria, Jugendstil, were the basis for the architectural treatment of two important subway systems of this period; the Paris Metropolitan built between 1898 and 1901, and the Vienna Stadtbahn, 1895-1901. Primarily a decorative style, Art Nouveau was particularly well suited to the sort of applied embellishment required for a subway project.

The stations for the Paris Metro were designed by the renowned Art Nouveau architect Hector Guimard. They were executed in a special kind of wrought iron with highly plastic qualities, as was most Art Nouveau design, and consisted of both enclosed above-ground station houses and simpler arched constructions over the entrance stairs. [8] In Vienna, Otto Wagner, another well-known architect, was chosen as designer for the Stadtbahn. His stations were somewhat more subdued than Guimard's, but display the same flowing floral patterns that characterize Art Nouveau.

Pevsner points out that Art Nouveau, like the contemporary Arts and Crafts movement in England, is "'Transitional' between Historicism and the Modern Movement." [9] While not a truly modern style, Art Nouveau can at least be termed progressive, because "the frenzy of its insistence on unprecedented form places it beyond that (19th) century of historicism." [10] Why, then, with a progressive precedent already set by European underground transit, was the New York subway carried out along traditional lines? The answer to this question lays with both the personalities involved and with an aesthetic movement which was peculiarly American--the City Beautiful.

American architecture during the last two decades of the 19th century is particularly hard to characterize, for a number of trends were occurring simultaneously. Louis Sullivan and others were at work in Chicago producing buildings relatively free from historical precedent. At the same time, and particularly in the East, an academic revival was being inaugurated by such buildings as the Villard Houses (New York, 1883) and the Boston Public Library (1888-1895), both by McKim, Mead and White. [11] But it is the White City of the World's Columbian Exposition of 1893 in Chicago which epitomizes the academic reaction, and marks the beginning of the movement known as City Beautiful. The aesthetic and intellectual motives of the City Beautiful, along with the general attitude of political and social reform during the period, were the most powerful influences upon the architectural treatment of the New York subway.

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An excellent indication of these attitudes toward civic betterment is embodied in the periodical Municipal Affairs, published by the Reform Club of New York from 1897-1902. This journal included numerous articles on "Municipal Art" which stressed the aim that art be "indigenous" and "not relegate(d)...to the exclusiveness of aristocratic appreciation," [12] and that "art must appeal to the great masses of the public to regain its educational influence" and produce the "better impulses of the people." [13]

The December, 1899 issue of Municipal Affairs was devoted entirely to "Civic Art," in conjunction with a conference on the same subject held in Baltimore on December 14-15 of that year. Civic art was seen as contributing to increased real estate values and tourism. A plea was made for the introduction of stained glass and the increased use of color on public buildings--two suggestions that would be followed in the design of the IRT.

Paris was held as the embodiment of the City Beautiful and several organizations attempted to force New York into the Haussmann mold. Patrician "civic art" associations such as the National Academy of Design, the Municipal Art Society, the Architectural League, the Art Student's League, the National Sculpture Society, and the Fine Arts Society produced noteworthy if somewhat fantastic plans for beautifying New York City. Among these were plans for introducing radial avenues into New York's gridiron street plan, and for erecting a Renaissance dome atop the Sixth Avenue elevated train station at Herald Square. [14]

American architecture of this period was under the influence of the great French architectural school, the Ecole des Beaux-Arts. Many American architects traveled to Paris for study at the Ecole, and this training often placed them at the forefront of the profession upon their return. Included in this group were Richard Morris Hunt, H. H. Richardson, Louis Sullivan, and Charles Follen McKim.

The Beaux-Arts system of design emphasized logical thinking to solve a "problem" in architecture. A thorough study was required to evolve a satisfactory plan, and the elevations of a building would naturally grow out of that plan. No specific historical style was mandated by the Ecole, but in accordance with the architectural theory of Viollet-le-Duc, [15] the abstract principles behind a given style were to be applied to a modern problem. Architects who returned to America from the Ecole, however, brought not only a knowledge of Beaux-Arts principles, but a taste for French Renaissance architecture as well. [16]

The influence of the City Beautiful movement was brought to bear on subway construction on January 31, 1901, the date when the Rapid

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Transit Commission appointed three of its members--Commissioners Rives, Smith, and Langdon--to a search committee whose job it was to choose both a consulting architect and an electrical engineer. [17]

Several different architectural firms were considered during the early months of 1901, the first of which was the prominent New York partnership of Carrere and Hastings. [18] Both John M. Carrere and Thomas Hastings had studied at the Ecole des Beaux-Arts and had met while employed as draftsmen in the office of McKim, Mead and White. As might be expected, their Beaux-Arts training inspired them with a preference for the architecture of the French Renaissance. This can be easily seen in two of their most famous works: the New York Public Library, 1897-1911; and the arch and colonnade of the Manhattan Bridge, 1905.

Also considered was Robert W. Gibson, another fairly prominent architect who received his architectural training in Britain. Gibson's architectural vocabulary was more eclectic than the Beaux-Arts practitioners, exemplified by his most well-known work in New York--the Flemish-inspired West End Collegiate Church of 1893 at West End Avenue and 77th Street.

But Commissioner Langdon was opposed to Gibson, and Carrere and Hastings apparently required too large a fee. [19] On March 7, 1901, on the recommendation of the search committee, the Board appointed Messrs. Heins and LaFarge as consulting architects at a fee of \$2,500 per annum, plus disbursements. [20] Heins and LaFarge had designed a chapel for August Belmont, II, in 1899 as part of their larger commission for the Cathedral of St. John the Divine, and Belmont, President of the IRT company, probably brought them to the attention of the committee. [21]

George L. Heins and Christopher Grant LaFarge are remembered today as ecclesiastical architects, most notably for the design of the Cathedral of St. John the Divine, which they won through competition with sixty other firms in 1891. [22] While their most famous works were churches, they also executed designs for numerous private homes and secular buildings during their partnership from 1886 until the death of Mr. Heins in 1907.

Both were educated at the architectural school of the Massachusetts Institute of Technology, the first school of architecture in the United States, which began in 1868. [23] The curriculum at MIT was, like the Ecole des Beaux-Arts, based mainly on logical planning and design. The design instructor, Eugene Latang, under whom Heins and LaFarge most likely studied, had been imported directly from the French school. Upon graduating from MIT, LaFarge took an internship

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in the office of H. H. Richardson, another product of the Ecole and one of the most influential architects of the 19th century. The internship had probably been arranged by LaFarge's father, John, who had done the interior decoration of Richardson's Trinity Church in Boston.

Hence, Heins and LaFarge received an education based on Beaux-Arts theory, but with one important difference. They were not continually exposed to French Renaissance architecture as a student in Paris would have been, and free from this influence, their approach to design more properly followed Beaux-Arts principles than most students directly in contact with the Ecole. As LaFarge said:

"Every new building is a new problem and every successful work of art a problem solved; the solution will be found through the comprehension of underlying principles and their application to the end in the spirit of our own time, and just insofar as this is the case will the work have merit, and beauty, and originality--be, in short, a work of art." [24]

On the matter of style, LaFarge believed it "trite to say that tradition must be followed." He abhorred "the servile, thoughtless imitation, the making of dull, lifeless, archeological copies of the works of long dead hands," for "the rules of grammar and the basic principles of art are no hindrance to freedom of thought or expression." [25]

The actual buildings by Heins and LaFarge accord well with the above statements. A full range of historical styles was employed, but all were adopted to their particular situation to avoid any hint of academic pedantry. One of their earliest designs is the Reformed Episcopal Church of the Reconciliation, constructed in 1890 on the southeast corner of Nostrand and Jefferson in Brooklyn. It is a small church designed in an extremely simplified Romanesque style. The Reformed Episcopal Church of the Reconciliation may have been only a study for the building which made Heins and LaFarge prominent--the Cathedral Church of St. John the Divine. St. John the Divine was a mammoth edifice originally designed in a style derived from "the time of transition from the simpler Romanesque to the more complex organism." [26] Complex was a more appropriate adjective for the Cathedral; notwithstanding its sheer size, the exterior detail (round-arched) was extraordinary. The original plan featured an immense tower over the crossing that would have been visible for miles.

In the design for St. Matthews Roman Catholic Cathedral (1893-1899, 1909-1910) in Washington, D. C., Heins and LaFarge looked for

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inspiration to the Renaissance churches of northern Italy. The simple, straightforward design juxtaposes walls of red brick against a great green copper dome; the church being an example of "excellent detail, workmanlike construction, and colorful decoration." [27] One more ecclesiastical building of note is the Grace Church Clergy House (1902) at 92 Fourth Avenue in Manhattan. Part of a complex of three houses, the Clergy House was designed in a Gothic Revival style to harmonize with its two neighbors and with James Renwick's nearby Grace Church (1846). Numerous private residences were also designed by Heins and LaFarge. Examples include three Georgian Revival town houses (1892) at 488-492 Fourth Street in Park Slope, Brooklyn, and the handsome neo-classical town house at 9 East 68th Street in Manhattan, constructed for George T. Bliss in 1906. [28]

Even a cursory study of the buildings designed by Heins and LaFarge reveals them to have been versatile, creative architects. Nowhere is this more evident than in the buildings they designed for the New York Zoological Park, Bronx, New York, between 1899 and 1911. These buildings, like the station houses for the IRT that will be detailed shortly, had few prototypes elsewhere in the world that could serve as examples. Heins and LaFarge's solution was a small formal allée, probably influenced by Chicago's Columbian Exposition. Around this court stood symmetrically placed buildings of buff-colored Roman brick, ornamented by neo-classical details executed in terra-cotta. But a closer look reveals lions in the cornice, lizards in the frieze, and elephants in the cartouche; an architecture of fantasy, perfectly suited to a pleasure ground.

The stations of the New York subway required an approach quite different from any of Heins and LaFarge's previous commissions, for here they were not working with space but merely with decoration. The station plans were determined by the engineers of the Board of Rapid Transit Railroad Commissioners, under Parsons' direction, and the architects were called in to "garnish" the spaces over which they exerted little direct control. This division of labor between the architect and the engineer, and between building construction and building art, is a major theme of architectural history before the modern movement. [29] The IRT illustrates this theme throughout its construction, albeit exaggerated by the fact that it was primarily an engineering work. But compare it with a modern subway system--for example the Washington Metro. Here little distinction exists between building construction and art; the coffered vaults and the dramatic spaces serve both purposes. So, in addition to lending insight into the working relationship of architect and engineer, the subway provides an illustration of an essentially 19th-century approach to construction and decoration.

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There were 49 stations on the Contract One subway, thirty-seven underground and twelve above. The underground stations, except for City Hall (which is unique and will be treated separately), were of two basic types: local, with platforms located on the outside of the tracks; and express, with island platforms between the local and express tracks. They were located at intervals of approximately one-half mile between locals, and one and one-half miles between express stations. (The accompanying inventory provides detailed information on individual stations.)

A guiding principle for station design was to keep the platforms as close to the street surface as possible to avoid the use of mechanical means of access. This was accomplished at all stations except 168th, 181st, and Mott Avenue, where the subway was in deep tunnel and convenient access necessitated an elevator. The interior of these stations is large arches similar in construction to the tunnel itself.

No two station plans were exactly alike, but the standard local station was a "T" shape, with "arms elongated parallel to the track," and "stem...under the street transverse to the main route." [30] Beneath the cross street was located the control area, about thirty by forty-five feet in area, with ticket booth and lavatories. The platforms were four feet above the base of the rails, two hundred feet long, and between ten and twenty feet wide. [31] On each platform were four stairways, two for entrance and two for exit, divided by metal gates operated by an attendant who controlled passenger flow. This separation of entrance and exit was similar to the Chemin De Fer De Sceaux in Paris that had so impressed Parsons. [32] At some of the stations, 23rd Street being the best example, arrangements were made with owners of adjacent properties for access directly from the station into their buildings.

Express stations were designed to accommodate both local and express trains. There were five of this type: Brooklyn Bridge, 14th Street, Grand Central, 72nd Street, and 96th Street. Platforms at these stations were arranged between the local and express tracks to allow for transfer between trains. At Brooklyn Bridge, 14th Street, and 96th Street, side platforms were provided in addition to the island platforms. The express stations were three hundred fifty feet long and varied in width from fifteen feet six inches at 72nd Street to thirty feet at 14th Street. Access to Brooklyn Bridge, 14th Street, and Grand Central was gained via an overhead mezzanine which required that the rail level be lower than at the local stations; about twenty-five feet in these three stations as opposed to seventeen feet for the locals. At 72nd Street (as at 103rd, 116th Streets, and Mott Avenue), the control area was located in an ornamental house,

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with the access directly from this house to the island platforms located only fourteen feet below the street. And at 96th Street a large trunk sewer necessitated that an underground passage be built below the tracks instead of a mezzanine.

The construction method employed for the stations is basically the same as that of the subway proper; that is, steel beams five feet between centers with jack-arch concrete roofs and either straight or jack-arch concrete walls (see photos 71, 72, 73). An additional inner wall of four-inch brick was built in the station areas, and separated from the outer structural wall by a one-inch air space to control water leakage and condensation (see photo 53). Ventilation openings were left in the wainscot of the lower wall area and in the cornice near the ceiling. Columns were placed at fifteen-foot intervals to carry the roof over the station platform, these columns being of round cast iron for "a better architectural effect." [33] Station floors were made of three-inch thick concrete divided into three-foot squares and graded to drain at one or more points. All stairways were of reinforced concrete (see photo 58). Two toilet rooms were provided on each platform. These were divided in half, one being free and equipped with only a water closet, the other requiring payment and provided with mirror, soap dish, and towel. These toilet rooms were supplied with an electric fan and heater.

One important aspect of station construction, contemplated "to be a very pleasing feature to the traveling public," [34] was the use of overhead vault lights to supply natural light to the stations (see photos 20, 54). These were installed wherever the platforms came beneath a public sidewalk or other right-of-way, and were utilized at twenty stations. Tests were carried out on several types of vault lights, and the chosen design consisted of circular glass lights two and three quarter inches in diameter set four inches between centers into reinforced concrete two inches thick. The steel reinforcing rods were extended beyond the concrete and attached to the flanges of the steel beams that supported them. Artificial lighting was supplied by incandescent bulbs set into ceiling recesses or held by brass fixtures.

All of the station work described thus far was designed by the engineers of the Rapid Transit Board under Parsons' direction. [35] The raw brick walls and concrete ceilings were then turned over to Heins and LaFarge to be "beautified" (see photo 69). The decorative scheme that they devised was certainly influenced by Parsons, for it is again similar to the Paris Chemin De Fer De Sceaux in its system of wall division and ornamentation. Heins and LaFarge's plans were subject to the final approval of Parsons, who delegated authority to D. L. Turner, assistant engineer in charge of stations for the Rapid

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Transit Subway Construction Company. August Belmont also oversaw station decoration; he approved of the first completed station at Columbus Circle, but complained of the use of too much brick at Astor Place, 50th Street, and 66th Street. [36]

In general, the station finish (see photos 25, 45, 46, 49, 50, 51, 56, 76, 78) consisted of a sanitary cove base that made the transition from floor to wall, upon which rested a brick or marble wainscot for the first two and one-half feet or so of wall area. This wainscot was applied to withstand the hard usage that the lower wall would be subjected to. The wainscot was completed by either a brick or marble cap, and the remainder of the wall area was covered with three-by-six-inch white glass tiles, completed near the ceiling by a cornice or frieze. The wall area was divided into fifteen foot panels, the same spacing as the platform columns, by the use of colored tiles or mosaic "in order to relieve the monotony that a plain-tiled surface would present." [37] The full station name appeared on large tablets of either mosaic tile, faience, or terra-cotta at frequent intervals, while smaller name plaques were incorporated into the cornice every fifteen feet. Sharp corners were eliminated and junctions between walls were curved to prevent chipping and facilitate cleaning. Ceilings were finished in one-inch thick white plaster applied to wire lath hung on channel irons at intervals of twelve inches. The channel irons were secured to beams and girders with metal clips, with a minimum one-inch air space left between the finished ceiling and the structural roof. The lath and plaster either followed the contours of the jack arches, with ornamental moldings in low relief accentuating the beams, or were suspended flat with ornamental moldings dividing them into panels.

Beyond this general treatment the stations exhibit considerable variation in color and detail. A conscious effort was made by the architects to create a distinct wall treatment for each station, both to relieve monotony and assist in the identification of different locations, and the "extent of the decoration varies with the relative importance of the stations." [38] Wherever possible, a local association was worked into the decorative scheme, such as the seal of Columbia University at 116th and Broadway [39] (see photos 206, 221). Heins and LaFarge used a number of different details to add interest to the stations. All of them were classically derived but designed with considerable artistic license. Examples of these details include the cornices at all stations, garlands such as at 116th and Broadway, cartouche such as at Spring Street and along the Lenox Avenue line, and flat pilasters and Greek Frets such as at 79th and 86th Streets. Ticket booths were of five different designs according to the amount of space available in the control area.

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Color was the most important artistic device used in the subway stations. As mentioned earlier in connection with Civic Art, color was thought to appeal to the average person more than subtle differences in scale or detail. As Herbert Croly observed in the Architectural Record:

"The ordinary man has no experience or standards which enable him to appreciate a building whose merit consists in effective proportions...in well distributed masses and well-scaled details. Architecture whose chief merits consist in such qualities must always be...inaccessible and...uninteresting...to the majority of people. General use of livelier colors...will...result in attracting popular attention to good design and in a more effective popular education in architecture. This color theory has been put to practice in...the stations of the New York subway. The result is... successful...." [40]

The quality of materials specified by Heins and LaFarge for use in the stations was extremely high. The wainscot was constructed of either buff-colored Roman brick [41] or marble. The vent grills and light fixtures were of bronze, and the ticket booths of oak. Encaustic mosaic tile was used for the color bands and name tablets. Architectural details were executed in either glazed terra-cotta or in faience for the more important stations. Faience is terra-cotta with a more refined glaze requiring two firings which produce an opaque mat glaze. [42] The materials were of such high quality, in fact, that their use had to be curtailed because of expense. Parsons noted in his construction diary, February 27, 1902, that he discussed reducing the expense of stations with LaFarge. By January, 1903 Parsons advised a simpler treatment for stations, and by the next month he ordered that the use of marble should be discontinued except for those stations already contracted for. [43]

Four of the stations, 72nd Street, 103rd Street, 116th Street, and Mott Avenue, were reached through ornamental control houses. [44] The idea for these control houses may have come from the Boston subway, where a small ornamental house served as the entrance to the Scollay Square station. Parsons and LaFarge had visited Boston in May, 1901 to examine "the various architectural features" of that subway. [45] The control houses of the New York subway were fanciful constructions which did not adhere to any strict historical style. They were similar in appearance and materials to the buildings by Heins and LaFarge at the New York Zoological Gardens and were ornamented with classically

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derived details. All were framed with steel "I" beams. The engineers of the Rapid Transit Commission were responsible for the design of the steelwork, but Heins and LaFarge executed the basic design and details. [46]

The control house at 72nd Street, completed in 1904, is still extant and in use (see photos 209, 210). The architects took advantage of a triangular parkway and placed the building at the same angle as Broadway to create a focal point in Sherman Square. The building is fifty by thirty-seven feet in size, and rests on a granite block foundation. It is one story tall and faced with buff-colored Roman brick. Limestone quoins at the corners support a low gable roof of terra-cotta blocks covered with copper sheets with raised joints. A limestone string course ties the building together horizontally and is broken by projecting sills of single-sash, center-pivot windows placed just below the eaves. Projecting bays on the north and south sides define the entrance and exit. These bays are topped by shaped gables with terra-cotta coping and four round terra-cotta finials. The numerals 72, placed in a terra-cotta cross, are centrally located near the top of this gable, and a glass and louver monitor connects the two gables along the roof ridge. The entrance and exit are formed by four side-hinged doors (a fifth has been added to the entrance side) topped by a small pediment and a window decorated with wrought iron scrollwork. The entire entrance is framed by a modified Gibbs surround executed in limestone. The interior contains the ticket booth, lavatories and five stairways, and is finished in white glass tile.

The control houses at 103rd and 116th Streets, also completed in 1904, were nearly identical and situated in the median strip of Broadway (see photos 26, 27, 35). They were fifty by twenty feet in size, gable roofed with monitor, and constructed of the same materials as the control house at 72nd Street. Limestone pilasters topped by anti-fixae divided the side elevations into four equal size bays, each pierced by three center-pivot windows. A limestone string course surrounded the buildings at the level of the sills. The gable ends were ornamented by limestone triglyphs below the eaves. Above the eaves, terra-cotta volutes supported a shaped gable with terra-cotta coping and a round finial at the top. A central bull's eye bore the station name, and this was decorated by a banded wreath above the key-stone of the door surround. One entrance on the main elevation led to the ticket booth and a wide stairway which descended to the mezzanine above the tracks.

The Mott Avenue control house, completed in 1905, is still extant, though altered and no longer used as a station entrance (see photo 245). It is situated near the southwest corner of 149th Street and Grand Concourse in the Bronx and is finished on the street facade with Roman

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brick and limestone trim. Entrance was gained through a porch which extended beyond the building line and has been removed. The porch featured three large windows divided by pilasters on the front and double entrance doors located on the sides. The building is finished at the top with a glazed terra-cotta cornice and a large name tablet of faience in three colors.

The entrance and exits of many other stations were covered by kiosks (see photo 59). These highly ornate constructions in cast iron and glass were inspired by similar structures of the Budapest underground railway, which Parsons presumably saw during his European visit. [47] The final design was executed by Heins and LaFarge, but it is so similar to the Budapest model that it cannot be considered their own idea. One hundred thirty-three kiosks were manufactured by the Hecla Iron Works, Brooklyn, in four standard lengths of 17'2", 19', 21'8", and 25', and widths varying from 4'3" and larger. [48] The roof designs differed so as to designate them as exits or entrances. The entrance kiosk featured a domed roof with leaf-like shingles of cast iron, while the exit was topped by a four-sided peaked skylight of one-quarter inch wire glass.

Aside from their strictly ornamental role, the kiosks performed certain utilitarian duties as well. The station toilet rooms were located directly below them and vent flues carried air up through one of the kiosk columns for discharge through perforations in the cornice soffit. A small vent near the bottom of each kiosk directed fresh air back down to the toilets, and another column was utilized as a sewer vent.

Although the kiosks became almost trademarks of the IRT company--they adorn the cover of the 1904 publication, Interborough Rapid Transit--they were not highly successful additions to the streetscape of New York City. The targets of vandals and advertisers besides being impediments to traffic, the kiosks were gradually removed and not one exists today (see photos 58, 75).

The stations along the elevated portions of the IRT were also designed by Heins and LaFarge. They were quite similar in plan to the stations along the existing elevated railway lines in Manhattan: two stairways on each side leading to a control house over the cross street, with semi-covered platforms extending along the tracks (see photo 34). The massing of the IRT elevated stations was less picturesque in character than the older elevated stations. Nevertheless, they retained an appearance that was essentially Victorian, and it can be assumed that Heins and LaFarge had used the existing elevateds as prototypes.

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The elevated station houses were entirely steel framed, with wood siding covered with copper sheets (see photos 39, 41, 67, 244). They featured a low hipped roof pierced by ventilating dormers on two sides and adorned by iron cresting along the ridge. The exterior surfaces were divided into panels with a wall dormer projecting from the street side. This dormer was ornamented with circular panels, topped by a small cornice and a semi-circular starburst flanked by five finials. The covered stairways descended in three stages, and they were enhanced by ornamental iron work. Platforms were roofed for a short distance on either side of the control house, and then extended alongside the tracks with an iron guard rail divided by lampposts at short intervals. The interiors were unfinished, with steel beams exposed, and contained the ticket booth, waiting room, and lavatories.

Two elevated stations, 125th and Broadway and Dyckman Street, differed from this standard plan. [49] The height of the Manhattan Valley Viaduct necessitated a smaller structure placed lower than the level of the tracks, and this structure was purely utilitarian in appearance (see photos 47, 223). At Dyckman Street the station was situated atop a masonry viaduct, and the control area was located below the tracks within this viaduct (see photos 61, 62, 68). The viaduct was constructed of dressed granite with shallow rustication. Large arched windows with decorative keystones supplied light for the control room which was finished with smooth plaster walls and a brick wainscot.

One more station of the New York subway is yet to be described--City Hall. [50] It was the southern terminus of the Contract One railroad, and was treated in an elaborate manner to serve as the showplace of the system. The City Hall station and the main powerhouse both exemplified the important role of architectural designs in the subway, but their treatment reflects two entirely opposite approaches to architectural design.

The original plan for the southern end of the Contract One subway arranged the four tracks on a loop below City Hall Park and extending beneath the United States Post Office that was then situated on the southern tip of the park. With the anticipation of the Brooklyn Extension (Contract Two), the plan was changed in 1898 to a smaller single track loop for local trains only, with the express tracks built overhead to avoid a grade crossing. [51] Because the loop was single track and curved, the station designed for it was unique from all the others. City Hall station, as designed by Heins and LaFarge, featured two short stairways leading from the street to a vaulted control room. A wide stairway then descended to the platform. The floors and wainscot were finished similar to the other underground stations, but the curve of the platform was accentuated by a series of timbrel vaults supplied by the R. Guastavino Company, New York.

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Guastavino vaults were constructed of thin terra-cotta tiles bonded with a string mortar and added in successive layers to form a thin structural vault of great strength [52] (see photos 23, 43). Heins and LaFarge were experienced with the principles of Guastavino vaults, for they had utilized them for the main crossing of the Cathedral of St. John the Divine.

The Guastavino vaults in City Hall station were of white mat-finish tiles, emphasized near the edges with green and brown glazed tiles. Three of the vaults had leaded glass skylights which opened upwards to vault lights in City Hall Park, as did the central skylight in the control room. Additional lighting was supplied by twelve chandeliers hung from the center of the vaults, plus incandescent bulbs around the platform entrance and in the control room. Three glazed terra-cotta name plates were located along the platform walls (see photos 21, 24, 44, 55, 74, 240, 241, 242, 243).

City Hall station, with its elegant use of vaulting and leaded glass, reflected the fact that Heins and LaFarge were masterful church designers. It was also the only subway station in which decorative design was related to structural form. Whereas the other stations and structures relied on applied historicizing decoration, the beauty of City Hall station was the result of structural elements directly tied to its peculiar plan.

Even though the City Hall station was symbolic of the care given to artistic treatment of the subway, it had its drawbacks as an icon. It was small, underground, and viewed only by those who happened to pass through it. And because the subway was only an intra-urban rapid transit railroad, there was no need for a large and conspicuous terminal. Lacking a Grand Central or St. Pancras, the IRT company lavished its attention on the main power house to make it the symbol of the company befitting the goals of the City Beautiful movement. Originally conceived as a structure of "massive and simple design... it was finally decided to adopt an ornate style of treatment by which the structure would be rendered architecturally attractive and in harmony with the recent tendencies of municipal and city improvements..." [53]

The power house occupied an entire block bounded by 58th and 59th Streets and 11th and 12th Avenues. [54] The structure was designed by the engineers of the IRT company under the direction of Paul C. Hunter, Architectural Assistant. [55] It was constructed of steel and reinforced concrete, divided by a brick partition wall down the center into an operating room on the north side and a boiler room on the south side. The facade was essentially free-standing, so the power house was really two buildings wrapped in a facade to appear as one.

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The facade was designed by Stanford White of the firm of McKim, Mead and White, the most prominent architects in New York City at the turn of the century. White purportedly "volunteered his services to the company," [56] but office records indicate that he was paid a stipend of \$3,500 for the design. [57] Whether this was a gift or an actual fee is unknown, but it attests to the importance that the power house held to the Interborough Company.

Many power houses that existed previous to the one detailed here, including the Manhattan Railway Company's 74th Street plant, utilized a series of repeating arches down the length of their facades in a manner that could be described as simplified Romanesque. This treatment created a pleasant rhythm and could be extended indefinitely if the structure was of great size. The study drawings for the IRT power house indicate experiments with this sort of treatment. The elevations featured unadorned arches topped by window openings becoming smaller in size but greater in number toward the top of the composition, in much the same manner as H. H. Richardson's Marshall Field Warehouse (Chicago, 1885-1887, demolished). But the length of the power house rendered this solution extremely "busy" and rhythm gave way to tedium. A more effective means of dividing the facade into bays was needed, and as the design progressed the solution was found in details adopted from Renaissance facades.

The final solution as conceived by White was a stunning Beaux-Arts Renaissance facade (see photos 154, 155, 156, 251). Its compositional scheme owed much to the Boston Public Library, although the power house details were overblown, less in keeping with the proper proportions of the classical language of architecture. The building stood on a low basement of smooth granite pierced by triple windows on the south facade only. Above this basement the north and south facades were identical. Pairs of rusticated brick pilasters divided the facade into equal bays articulated by tall arched window openings with decorative terra-cotta molding and keystones. Within the window openings cast iron sash glazed with ribbed glass in a star pattern screened out a view of the interior. The window arcade was capped with a small terra-cotta cornice, and above this a narrow band of pilasters and triple window openings corresponded to the arcade below. The main cornice (now removed) and a low parapet completed the composition. The main facade along 11th Avenue was similar, but featured single pilasters creating narrower bays. Sculptured terra-cotta import blocks ornamented the pilasters, and marble medallions were placed above the window keystones. The west facade was left unfinished in anticipation of a future addition.

The corners of the power house were slightly set off from the main wall plane with the primary entrance on the northeast corner,

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the design's only concession to asymmetry. Large openings were cut into the north and south facades near the east corners to allow a railway spur of the New York Central to pass through the building. Six huge chimneys rose from the south side of the roof, which was finished in terra-cotta tile and fitted with a glass clerestory. [58]

The main power house was the most high-style piece of design for the subway system. It was a significant example of the academic classicism of which McKim, Mead and White were the acknowledged masters. But by its correctness and symmetry it masked completely the functions which took place within it; only the chimneys gave hint of its industrial purpose.

In addition to the main power plant, eight power sub-stations were located along the route of the subway system. [59] They were designed by Paul C. Hunter of the IRT company, with the assistance of the company's engineers. Six of the sub-stations were nearly identical: numbers 12, 13, 14, 15, 16 and 18. They were all approximately fifty by one hundred feet in size with some variation due to lot size and land availability, and were finished on the street facade only. [60]

The sub-stations were constructed on thick brick foundations with brick walls and reinforced concrete floors and ceilings. All were steel framed throughout. Their basic plan was three bays wide by six bays long, [61] with a basement and one main operating room with a gallery in the rear (see photo 257). The front portion of the buildings was taller than the rear and contained battery rooms or office space. These additional floors were reached by an ornamental iron staircase or a steel-cage elevator (see photo 256). [62] A V-shaped air well with lowered skylights ran longitudinally down the center of each sub-station to provide light and ventilation for the operating room (see photo 255). Roofs were flat with brick parapet walls, which rose in stepped sections to the level of the facade (see photo 253).

The facades, also designed by Hunter, were intended to blend in with the streetscape and mask the interior functions (see photos 254, 259, 270). Most of the sub-stations were located on residential streets. The facades were tri-partite compositions utilizing Beaux-Arts Renaissance details. The first story (which bears no relation to any interior division) was a rusticated limestone base broken by two double doors with a window between. In the middle section terra-cotta blocks stood out from a brick background to frame a double window grouping topped by a large cartouche surrounded by foliate ornament. A prominent string course made the transition to the upper story, which consisted of a row of five evenly spaced windows topped by an immense cornice held by overscaled brackets.

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Sub-station number 11 (see photo 28) on City Hall Place (now demolished) was identical to those already described except for facade details. The base of sub-station 11 featured a central entrance surmounted by a segmental arched pediment supported by brackets. A banded wreath with festoons ornamented the middle section, and the composition terminated with a sloped mansard at the top.

Sub-station number 17 on Hillside Avenue departed from this (photo 7) general pattern. It was built on undeveloped land and hence was freestanding and finished on four sides. Its interior arrangement was similar to the other sub-stations, but the central light well was omitted and a full second floor was built. This floor housed a foundry and machine shop and is presently used for storage. The exterior was brick with limestone and terra-cotta trim. Windows on the side elevations were evenly spaced--square for the first row, segmentally arched for the second, and round-arched on the third. Terra-cotta string courses ran horizontally around the building. Two hipped roof towers surmounted the front corners. These were ornamented by terra-cotta festoons. The main roof was hipped and constructed of terra-cotta blocks covered by tin sheets with raised joints. A copper gutter system supported by large wrought iron brackets ran around the entire building.

Several other architectural embellishments need yet to be mentioned. The masonry work on the north and south ends of the Manhattan Valley Viaduct, and the north entrance to the Ft. George Portal was designed by Heins and LaFarge. The Manhattan Valley Viaduct approaches were constructed of rough-faced granite piers with brick infill (see photos 70, 226). A dressed-stone molding ran along the tops of the piers supporting a stone guard rail holding name plates ornamented with gattae. These name plates were never filled in. The north end of the Ft. George Portal at Dyckman Street was embellished with an arch of rough-faced stone voussoirs (see photo 42). A stone name tablet similar to those just described on the Manhattan Valley Viaduct commemorated the site of the Revolutionary War fortification, Ft. George.

The original rolling stock for the IRT subway was patterned primarily after that of the Manhattan Railway Company's elevated cars (see photos 36, 37). [63] But the special nature of the subway placed strict limitations and requirements on car design, notably: restricted heights and clearance for curves, the necessity for non-combustible materials, and most importantly, operation at higher speeds than any existing railway service. [64] These high speeds combined with frequent stops demanded a car of great strength but extremely light weight.

The first contract for rolling stock was let in late 1902 for five hundred cars of composite construction; that is, wood and steel

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frames with wooden bodies sheathed with copper. [65] Although the management of the Interborough Company considered an all-steel car from the beginning, no car of this type had been constructed and no manufacturer could be found who would accept such a contract. So all energies were put into the production of the composite cars while details of the steel cars were given further study.

The composite cars were built according to designs of George Gibbs, consulting engineer to the Interborough Company, and W. T. Thompson, master mechanic of the Company. [66] They were wood-framed, reinforced with anti-telescoping steel bars to prevent excessive damage in the event of collision. The cars were fifty-one feet long, about four feet greater than existing Manhattan Elevated Railway cars, and provided seating for fifty-two passengers on rattan-covered seats arranged longitudinally near the car ends and face-to-face at the center. They differed in exterior appearance from the elevated cars for several reasons. First, the side walls sloped inward above the window sill to accommodate limited clearance in the tunnels. Second, the roof was lower for the same reason; and third, the cars featured enclosed vestibule platforms with sliding doors instead of the usual gates. These sliding entrance doors were located at the ends of the cars, and were operated by attendants. [67] Parsons, in his European visit in 1894, had found this end door arrangement preferable to side doors in distributing passengers. [68]

The interiors of the composite cars followed American practice and contained only one compartment, instead of first- and second-class areas as on many European systems. [69] One innovation in design was the arrangement of the platform wherein the vestibule could be either closed to make the car a distinct compartment or open to allow for passage between cars. Windows were double wooden sash with the upper sash movable. Floors were of hard maple with asbestos fireproofing beneath. Interior woodwork was light-colored mahogany, as was the overhead handrail. Lighting was supplied by incandescent bulbs and ventilation by a louvered clerestory.

While the composite car was in the process of manufacture, George Gibbs was at work trying to rectify the problems of fireproof steel car design. Among these problems was excessive weight, heat transmission, and noise. In December, 1903 a sample car was produced at the Pennsylvania Railroad Company plant in Altoona, Pennsylvania. The assistance of the mechanical department of the Pennsylvania Railroad was offered because that company anticipated the need for fireproof steel cars in their tunnels. [70] Although this sample car was still too heavy, Gibbs soon developed a second design for a car about the same weight as the composite. [71]

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The steel car designed and patented by Gibbs, and first introduced on the IRT subway, represented "the highest type of the car building art" in 1904. [72] Its most novel feature was the principle whereby the floor load was carried by the side framing of the car, eliminating the need for heavy under-trussing. The general appearance of the steel cars was similar to the composite, except that all surfaces were metal: rolled sheet steel on the exterior and sheet aluminum on the interior, with metal door and window framing and metal trim. The first contract for two hundred steel cars was given to the American Car and Foundry Company, Berwick, Pennsylvania, followed shortly by an order for an additional one hundred cars.

Two unforeseen problems developed shortly after the subway opened to the public in October, 1904: insufficient ventilation in the tunnels, and defacement of the station walls by advertisements. Both these situations were given immediate attention by the Rapid Transit Commission and the Interborough Company. The technical problem was solved; the legal problem was not.

Parsons had taken note of the methods of ventilation for underground transit in both European and American systems, and he commented extensively on them in his 1894 Report on Rapid Transit in Foreign Cities. The most common method for ventilation was simply to rely on the piston action of the moving trains to force air through the tunnel, bringing fresh air in through station entrances, open cuts, or specially provided blow-holes (openings). In Europe only the Glasgow Central Railway, the Liverpool Mersey Tunnel, and the Paris Chemin De Fer De Sceaux provided any mechanical means of ventilation: large fans or blowers which exhausted stale air. [73] The Boston subway employed a similar system, with ventilating fans placed in chambers alongside the tracks which forced the air out through grated openings in the sidewalks. [74]

The original design for the New York subway relied entirely on natural ventilation and piston action of trains to purify the air. Because the tunnel was located directly below the street and electric traction utilized for power, no mechanical means of ventilation seemed necessary. Frequent stations with many stairways, plus blow-holes located in the center of Broadway on that portion of the line north of 60th Street, provided openings for the circulation of air. [75] But complaints from the public concerning the purity of the subway air began shortly after the line opened, and the Rapid Transit Commission sought the assistance of Dr. Charles F. Chandler of Columbia University to test the quality of the air. Dr. Chandler's tests concluded that the subway air was surprisingly good. [76] Complaints continued, especially with regard to heat and odor, and in the summer of 1905, the Board commissioned George A. Soper to conduct a thorough investigation of the problem. [77]

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Soper concluded that the air, though disagreeable at times, was not harmful. [78] The high temperatures were due to the conversion of electric power into friction. [79] Odors were caused primarily by the stone ballast of the roadbed, the lubricants used on car machinery, and the general "newness" of tile cement and plaster. The most potentially harmful component of the air was dust produced by the grinding of metals, but not enough of this dust was inhaled by the average passenger to be harmful.

Pursuant to Soper's report, extensive changes were made in 1906-1907 to the ventilation arrangement of the New York subway. "Nowhere has so much attention been given this subject [improving ventilation] since electric traction came into use as in New York." [80] The simplest change was the removal of station vault lights for replacement by open gratings (see photos 64, 65). [81] Where the gratings occurred over the platforms, copper pans were placed below them to catch water. In the portion of the subway between Brooklyn Bridge and Columbus Circle, where no ventilation openings between stations had been provided in the original construction, fourteen ventilating chambers were constructed adjacent to the tracks between stations (see photos 63, 66). These chambers were controlled by automatic blowers which exhausted air out of grated openings, thus drawing in fresh air through stairways and gratings at the stations (see photo 40).

The most complicated piece of construction involving ventilation was an experimental cooling plant built at the Brooklyn Bridge station. This plant, designed by John E. Starr, consultant to the Rapid Transit Commission, utilized cold water pumped from the ground by electric pumps to cool a bank of pipes situated on the local platforms on each end of the station. This device reduced the temperature within the station by several degrees but, because of cost, was not utilized at other stations. [82]

Advertisements appeared in the subway stations within hours after the first trains began operation, and they were immediately "criticized by the aesthetic public (see photos 48, 57)." [83] The signs were placed in the stations by the Interborough Rapid Transit Company, but it was the Rapid Transit Commission, as lessor of the road, that the public held responsible. The Chairman of the Municipal Art Commission, John DeWitt Warner, declared that the Board displayed "a streak of barbarism...in having had the subway stations appropriately decorated and then permitting them to be littered out by the advertising junk..." [84] He went on to hope the signs would be "smashed by gentlemen" who had a perfect right "to kick or crush them in abatement of a nuisance." [85]

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The provision in the original contract stated that no advertisements were to be placed that would "interfere with the easy identification of stations or otherwise with efficient operation." [86] Obviously the Rapid Transit Commission was fully aware that the advertising signs would appear. One editorial went so far as to say that the money gained from advertising was one of the inducements which caused the Interborough Company to take the contract. [87]

Nevertheless, the Board was responsive to public pressure and carried on negotiations with the Interborough Company in an attempt to arrive at some general guidelines for sign placement. These negotiations proved futile, and in February, 1905, the Manhattan Borough President notified the Interborough Company that all signs were to be removed. [88] The Interborough Company then began legal action against the City and the Borough President, and obtained a temporary injunction against such action, which was continued as a formal injunction by the opinion of Mr. Justice Bischoff in a special term of the State Supreme Court. [89]

On January 8, 1906, the formal case was tried at an equity term of the State Supreme Court with the City of New York as plaintiff and the Interborough Company as defendant. [90] This case was to restrain the Interborough Company from placing vending machines and weighing machines in the stations, the question of advertising having been answered by the previous decision. The City obviously thought it had a better chance in court on the machine issue, since the original contract contained no clause with reference to vending machines of any sort. But this reason worked against them, and on December 24, 1906, Mr. Justice McCall handed down his decision in favor of the defendant. [91] The decision was based on the right of the Interborough Company, as leaseholder, to operate the machines as long as they did not affect the skillful operation of the road, which they did not. The court also sanctioned the machines and advertisements of "universal custom," a custom which was, on the basis of the court's decision, forever granted to the New York subway. [92]

Despite these problems, public response to the architectural designs of the New York subway was generally favorable. The New York Sunday Sun featured the headline "The City Beautiful: Its Beginnings Underground," and described the stations as "a delight to the eye." [93] The same article mentioned the power sub-stations as buildings that could be mistaken "almost for the home of a wealthy citizen whose fancy turned toward the heavy and impressive." [94] Another author described the journeys to work on the subway as "pleasure excursions...relieved here and there by commodious, well-lighted rooms, colored in a kaleidoscopic variety of tint." [95] The Record

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and Guide thought the new subway stations an immense improvement over the old elevated stations, and congratulated the city for its contribution to "Civic Art." [96] In fact, the only criticism, except for the advertising signs, was leveled against the control house at 72nd Street. Its fanciful design must have offended the sensibilities of West Siders, for on December 5, 1904, the West End Association adopted a resolution declaring the station house "not only an offense to the eye, but a very serious danger to life and limb," and requested that the Rapid Transit Commission remove it. [97]

The success of the artistic designs plus a four-year working relationship did not, however, succeed in reconciling the viewpoints of Parsons and LaFarge. Remarks that each made after the subway's completion indicate that while Parsons was a strict modernist, embracing every aspect of 20th-century technology, LaFarge remained an ardent traditionalist. Their viewpoints are illustrative of the almost antagonistic relationship between the professions of architecture and engineering in this period.

In an address before the Architectural League in 1911, Parsons, summing up the attitudes of the profession, could not repeat what most engineers thought of architects, "ladies being present." [98] He went on to describe an incident where he was "sufficiently rash" to suggest to the architect of a great cathedral that steel beams be utilized to create a church larger than any in existence, an obvious reference to LaFarge and St. John the Divine. [99] LaFarge replied that the use of steel would violate every "canon of the Gothic Art," [100] and later described the steel frame as "commercial...of unknown duration," and "instantly to be dismissed." [101] The abundant use of modern materials in the subway had not convinced LaFarge of their reliability; he thought concrete to be only "half-understood," and described it as "treacherous, but dear to the engineer." [102] The resolution of these differences between architect and engineer was yet a decade or two into the future.

Footnotes

- [1] Henry-Russell Hitchcock, Architecture: Nineteenth and Twentieth Centuries (Baltimore: Penguin Books, 1971), p. 531.
- [2] Report of the Board of Rapid Transit Railroad Commissioners, 1891, p. 72.
- [3] Contract for the Construction and Operation of a Rapid Transit Railroad, 1899, p. 156.
- [4] William Barclay Parsons, Rapid Transit in Foreign Cities, (New York, 1894).
- [5] Ibid., p. 9.
- [6] Ibid., pp. 46-47.
- [7] Nikolaus Pevsner, Pioneers of Modern Design (Baltimore: Penguin Books, 1960), p. 96.
- [8] An example of Guimard's work for the Metropolitan is preserved in the sculpture garden of the Museum of Modern Art, New York City.
- [9] Pevsner, op. cit., p. 107.
- [10] Ibid., p. 112.
- [11] These are major themes in American architectural history. See Fitch, American Building; Jordy, American Buildings and Their Architects, vol. 3; Burchard and Bush-Brown, The Architecture of America.
- [12] Frederick S. Lamb, "Municipal Art," Municipal Affairs, vol. I, no. 4 (December, 1897), pp. 682-683.
- [13] Ibid., pp. 682, 684.
- [14] Lamb, Municipal Affairs, vol. III, no. 4 (December, 1899), p. 631.
- [15] See "Viollet-le-Duc and the Rational Point of View," in John Summerson, Heavenly Mansions (New York: Norton, 1963), pp. 135-158.
- [16] Arthur Clason Weatherhead, A History of Collegiate Education in Architecture in the United States (Los Angeles: 1941), p. 75.

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- [17] Proceedings of the Board of Rapid Transit Railroad Commissioners, 1899-1901, p. 1130.
- [18] Construction Diary of William Barclay Parsons, January 25, 1901.
- [19] Ibid., February 1, 1901; and February 18, 1901.
- [20] Proceedings, 1899-1901, p. 1149.
- [21] C. Grant LaFarge, letter of December 1, 1899, to August Belmont, Esq.
- [22] Cathedral Church of St. John the Divine," (New York: St. Bartholomew's Press, 1916), p. 20.
- [23] Weatherhead, op. cit., p. 25.
- [24] C. Grant LaFarge, "The Cathedral of St. John the Divine," Scribner's Magazine (April, 1907), p. 385.
- [25] Ibid.
- [26] Ibid., p. 401. The Heins and LaFarge design was never completed. Upon the death of Mr. Heins in 1907, the church board adopted the plan of Cram and Ferguson.
- [27] John Burchard and Albert Bush-Brown, The Architecture of America (Boston: Little, Brown, and Company, 1966), pp. 221-222.
- [28] The Battery Park Control House (Contract Two), 92 Fourth Avenue, and 488-492 Fourth Street are designated New York City Landmarks.
- [29] See Pevsner, Pioneers of Modern Design; Gideon, Space, Time and Architecture; and Fitch, American Building.
- [30] William Barclay Parsons, "The New York Rapid Transit Subway," J. H. Tudsbery, editor (London: The Institution of Civil Engineers, 1908), p. 24.
- [31] Station dimensions vary because of local conditions, and all platforms have subsequently been lengthened.
- [32] Parsons, Rapid Transit in Foreign Cities.
- [33] Parsons, "The New York Rapid Transit Subway," p. 28.

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- [34] Report, 1903, p. 203.
- [35] All designed by the engineers of the Rapid Transit Board except the addition of a pay toilet, which was LaFarge's idea, and the brass light fixtures, which were designed by the architects.
- [36] Construction Diary, July 3, 1902; November 20, 1902; and February 11, 1903.
- [37] Parsons, "The New York Rapid Transit Subway," p. 28.
- [38] Ibid., p. 29.
- [39] This topic has been treated in detail elsewhere. See John Taurenac, "Art and the IRT," Historic Preservation (October-December, 1973), vol. XXV, no. 4, pp. 26-31.
- [40] Herbert D. Groly, "Glazed and Colored Terra Cotta," Architectural Record (April, 1906), vol. XXIX, no. 4, pp. 315-323.
- [41] This refers to the dimensions of the brick, 12x1 and 1/2 inches, and has been variously described as Roman, Norman, or "Pompeian."
- [42] The term faience as used during this period should not be confused with French faience or Italian maiolica of the 17th and 18th centuries, which were fine arts potteries with a tin glaze. See Arthur Lane, French Faience, and Sturgis Laurence, "Architectural Faience," Architectural Record, vol. XXI.
- [43] Construction Diary, February 27, 1902; January 6, 1903; and February 25, 1903.
- [44] Two more of these ornamental control houses were built on Contract Two, at Bowling Green and Atlantic Avenue, Brooklyn. Both are still extant.
- [45] Construction Diary, May 3, 1901.
- [46] This fact is based upon a drawing of the steel superstructure of the 116th Street control house by the Rapid Transit Commission engineers, and on the fact that no details of steelwork appear in the index of architectural drawings, Transit Authority, Brooklyn. On this basis, it can be assumed that Mr. Parsons' engineers designed the steelwork for all control houses.
- [47] For photographs of the Budapest kiosk, see Rapid Transit in New York City and in Other Great Cities, Chamber of Commerce of

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- [47] the State of New York, 1905, p. 312; and "Rapid Transit Subways (con't.) in Metropolitan Cities," Municipal Affairs (September, 1900), vol. IV, no. 3, p. 469.
- [48] Advertisement of the Hecla Iron Works, Catalogue of the 20th Annual Exhibition of the Architectural League of New York, 1905, p. 6A.
- [49] The western portion of 125th Street was formerly named Manhattan Street.
- [50] The City Hall station has been closed to the public since December 31, 1945, but the Lexington Avenue local (#6) still uses the loop to turn around.
- [51] Contract Drawing A1, April 7, 1898, Transit Authority Record Room, Brooklyn.
- [52] George Collins, "The Transfer of Thin Masonry Vaulting from Spain to America," Journal of the Society of Architectural Historians (October, 1968), vol. XXVII, no. 3, pp. 176-200.
- [53] Interborough Rapid Transit (New York: Interborough Rapid Transit Company, 1904), p. 74.
- [54] The power house dimensions were 200x594 feet. An addition was added to the west side in the late 1940s, according to the office staff of David Gigante, Consolidated Edison Company, New York.
- [55] Mr. Hunter obviously had aspirations to glory, for he published a plate of the power house in 1906 and signed his name only, giving no mention to White. See "Power House - Interborough Rapid Transit Company," Architecture (July 15, 1906), vol. XIV, no. 1, plate Ll.
- [56] Interborough Rapid Transit, op. cit.
- [57] "Bill Book," McKim, Mead and White; December, 1902-March, 1906, p. 146, at the New York Historical Society.
- [58] The roof profile and materials have been altered.
- [59] See the preceding section on electrical systems for the locations of these sub-stations.

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- [60] General information on these sub-stations was provided by Mr. Constantine Tsirickes and Mr. Dominick Cerbone of the New York City Transit Authority. My thanks to them for a most cordial tour of their facilities.
- [61] Sub-station #13 on West 53rd Street is seven bays long, and #12 on East 19th Street had a later addition to the rear. Photos 187, 190 depict the general structure details of all sub-stations except #17.
- [62] The elevators were installed only at sub-stations #14 and #17, although all sub-stations contained an elevator shaft. These two mentioned are still in operation and were manufactured by Marine Engine and Machine Company, New York, with controls by Otis Company.
- [63] "The Rolling Stock of the Manhattan Railway Company," Street Railway Journal (December 6, 1902), vol. XX, no. 23, pp. 907-914.
- [64] "The New Steel Cars for the Subway Division of the New York Interborough Rapid Transit Company," Street Railway Journal (October 8, 1904), vol. XXIV, no. 15, p. 635. Speeds were 15 miles per hour for the five-car locals and 35 miles per hour for the eight-car express trains.
- [65] Ibid.
- [66] The composite cars were manufactured by John Stephenson Company, St. Louis Car Company, Jewett Company, and Wason Company.
- [67] "How Sliding Doors on New Subway Cars will be Worked," New York Times, September 13, 1903, column 6, p. 28. According to Mr. Edward Crew of the New York Transit Museum, Brooklyn, automatic multiple unit doors were not introduced until the early 1920s and pioneered on the BMT lines.
- [68] Parsons, Rapid Transit in Foreign Cities, p. 57.
- [69] "Rapid Transit Subways in Metropolitan Cities," Municipal Affairs, op. cit., p. 479.
- [70] "Fireproof Cars for the New York Subway," American Engineering and Railroad Journal (March 4, 1904), vol. 78, p. 106.
- [71] The steel cars weighed 77,000 lbs. with trucks and motors, the composites, 72,000 lbs.

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- [72] "The New Steel Cars for the Subway Division at the New York Interborough Rapid Transit Company," op. cit.
- [73] Parsons, Rapid Transit in Foreign Cities, pp. 30, 35, 40.
- [74] George A. Soper, The Air and Ventilation of Subways (New York: John Wiley and Sons, 1908), p. 56.
- [75] Ibid., p. 113. A total of 18 blow-holes, 7 and 1/2 by 14 feet in size, were constructed between 59th and 96th Streets.
- [76] Ibid.
- [77] Report, 1905, p. 60.
- [78] Soper, op. cit., p. 189. See also Konrad Meier, "New York Subway Ventilation," Engineering Record (June 17, 1905); and "The Problem of Ventilation in the New York Subway and Similar Tunnels," Engineering News (June 22, 1905).
- [79] "The Cause of High Temperatures in the New York Subway," Engineering News (June 15, 1905).
- [80] Soper, op. cit., p. 97.
- [81] According to the 1906 Report, p. 8, 323 square feet of vault lights were removed between Brooklyn Bridge and 96th Street. This was the only portion of the line altered for ventilation improvement.
- [82] A thorough discussion of this cooling plant is contained in the 1906 Report.
- [83] Street Railway Journal (November 12, 1904), vol. XXIV, p. 893.
- [84] "Stations Defaced," New York Globe, October 29, 1904.
- [85] Ibid.
- [86] "Can't Stop Unsightly Ads," New York Times, October 29, 1904.
- [87] "To Stand by Subway 'Ad' Contract," New York Tribune, November 3, 1904.
- [88] Report, 1905, p. 59.
- [89] Interborough Rapid Transit Company against the City of New York and others, 47 Misc. Rep., 221, reprinted in Report, 1905, pp. 107-111.

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- [90] Report, 1906, p. 153.
- [91] Ibid.
- [92] Ibid., p. 155.
- [93] New York Sunday Sun, October 23, 1904.
- [94] Ibid.
- [95] The New York Subway Souvenir (New York: Burroughs and Company, 1904), p. 12.
- [96] "The Old Rapid Transit and the New," Real Estate Record and Builder's Guide (October 29, 1904), vol LXXIV, no. 1911, p. 896.
- [97] Proceedings, 1904, p. 2892. As an interesting aside, this same control house was recently sandblasted, and scores of neighborhood residents appeared in protest, lest the building be damaged.
- [98] William Barclay Parsons, "The Architect and the Engineer," an address before the Architectural League of New York, February 8, 1911, p. 1.
- [99] Ibid., p. 6.
- [100] Ibid., p. 7.
- [101] C. Grant LaFarge, "The Cathedral of St. John the Divine," Scribner's Magazine (April, 1907), vol. XLI, no. 4, p. 386.
- [102] Ibid.

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Underground Station Inventory

The following inventory contains information in addition to that given in the main text. If information on a given station was unavailable, it was deleted from the inventory without notation.

All stations have been altered and extended, but most still contain at least some original wall area, unless otherwise noted.

The following information refers to all stations:

Brickwork and masonry:	Dowd and Maslen, subcontractor
Facebrick:	Shade #59, Fredenburg and Lounsbury, agents
Colored mosaic tile:	American Encaustic Tile Company, manufacturer, installed by tile subcontractor as listed
Illuminated signs at express stations:	Pulsifer and Larson Company
Ticket booths and woodwork:	J. Odell Whitenack, subcontractor

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City Hall

Closed since December 31, 1945

Contractors:

Degnon and McLean Contracting Company
R. Guastavino Company

See main text for description and color scheme

Brooklyn Bridge

Material Subcontractors:

Grueby Faience Company, Faience

Most original wall area has been covered and station plan has been altered by later connection to the BMT lines

Worth Street

Station closed since September 1, 1962

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue/green tile tablets
Buff tile bands
Green terra cotta cornice
Buff terra cotta plaques

Canal Street

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue/green tile tablets
Green tile bands
Buff terra cotta cornice
Green terra cotta plaques

Platform Extensions:

North ends of both platforms

A connection to the BMT lines has been added

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Spring Street

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue tile tablets
Light blue tile bands
White terra cotta cornice
Light blue terra cotta plaques

Platform Extensions:

North end of uptown platform, south end of downtown

Bleecker Street

Material Subcontractors:

Grueby Faience Company, Faience

Color Scheme:

Blue faience tablets
Light blue tile bands
Blue faience cornice
Blue faience plaques
Marble wainscot cap

Platform Extensions:

North end of uptown platform, south end of downtown

The original ticket booth stands on the downtown side, and a connection to the BMT lines has been added

Astor Place

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Grueby Faience Company, Faience

Color Scheme:

Blue faience tablets
Blue tile bands
Green faience cornice
Blue faience plaques

Platform Extensions:

North end of uptown platform, south end of downtown

The original ticket booth stands on the downtown side, and an underpass connects the platforms

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14th Street

Material Subcontractors:
Grueby Faience Company, Faience

Color Scheme:
Blue tile tablets
Blue and buff tile bands
Yellow faience cornice
Blue faience plaques

The original ticket booth stands on the east control area.
Station has been drastically altered by the addition of the
BMT lines

18th Street

Station closed since November 8, 1948

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Grueby Faience Company, Faience

Color Scheme:
Blue/green tile tablets
Buff and violet tile bands
Violet faience cornice
Green faience plaques

23rd Street

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Rookwood Pottery Company, Faience

Color Scheme:
Black tile tablets
Violet and white tile bands
Grey faience cornice
Red faience plaques
Marble wainscot

Platform Extensions:
South ends of both platforms with additional
ticket booth and entrances

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28th Street

Material Subcontractors:
Grueby Faience Company, Faience

Color Scheme:
Blue faience tablets
Buff bands and cream glass tile trim
Blue faience cornice
Blue faience plaques
Marble wainscot cap

Platform Extensions:
Both ends of both platforms, with additional ticket booth and entrances on south ends

33rd Street

Material Subcontractors:
John H. Parry, Tiles
Grueby Faience Company, Faience

Color Scheme:
Blue tile tablets
Buff and green tile bands
Yellow faience cornice
Yellow faience plaques

Platform Extensions:
South end of both platforms with additional ticket booth and entrances

Grand Central

Now Grand Central Shuttle station, dead ended
No original wall area exposed to view

Material Subcontractor:
John H. Parry, Tiles

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Times Square

Now Times Square Shuttle station, dead ended

Material Subcontractor:

Grueby Faience Company, Faience

Color Scheme:

Blue tile tablet
Pink and blue tile bands
Multi-color tile pilaster
Buff faience cornice
Buff faience plaques

Original ticket booth on west (originally downtown) control area

50th Street

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Grueby Faience Company, Faience

Color Scheme:

Green faience tablet
Blue tile bands
Green cornice
Blue plaques

Platform Extensions:

North ends of both platforms

Original ticket booth on uptown side

59th Street/Columbus Circle

Material Subcontractor:

Grueby Faience Company, Faience

Color Scheme:

Green tile tablets
Green and red tile bands
Green cornice
Special plaques

Platform Extensions:

Both ends of both platforms, with connection to IND lines

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66th Street

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Grueby Faience Company, Faience

Color Scheme:
Yellow faience tablet
Buff tile bands
Yellow faience cornice
Blue faience plaques

Platform Extensions:
South ends of both platforms

Original ticket booth on downtown side

72nd Street

Material Subcontractor:
John H. Parry, Tiles

Color Scheme:
Multi-color tile panels, no faience or terra cotta

Platform Extensions:
Small extensions on north end of downtown platform,
south end of uptown

79th Street

Material Subcontractors:
Alfred Boote Company, Tiles
Rookwood Pottery Company, Faience

Color Scheme:
Green tile tablets
Buff tile bands
Multi-color tile pilaster
Blue faience cornice
Yellow faience plaques

Platform Extensions:
North ends of both platforms

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86th Street

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Rookwood Pottery Company, Faience

Color Scheme:
Blue tile tablets
Buff tile bands
Multi-color tile pilaster
Blue faience cornice
Yellow faience plaques

Platform Extensions:
North ends of both platforms

91st Street

Station closed since February 2, 1959

Material Subcontractors:
Alfred Boote Company, Tiles
Rookwood Pottery Company, Faience

Color Scheme:
Blue tile tablets
Green tile bands
Yellow faience cornice
Violet faience plaques

96th Street

Material Subcontractor:
Alfred Boote Company, Tiles

Color Scheme:
Red tile tablets
Pink tile bands
Buff cornice
Buff plaques

Platform Extensions:
South end of all platforms

The original ticket booths stand on both control areas

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103rd Street

Material Subcontractors:

Alfred Boote Company, Tiles
Grueby Faience Company, Faience

Color Scheme:

Green tile tablets
Green, pink, red tile bands
Yellow faience cornice
Blue faience plaques

Platform Extensions:

South end of both platforms

110th Street/Cathedral Parkway

Material Subcontractors:

John H. Parry, Tiles
Grueby Faience Company, Faience

Color Scheme:

Green tile tablets
Buff, pink, red tile bands
Green faience cornice
Blue faience plaques

Platform Extensions:

South end of both platforms

116th Street/Columbia University

Material Subcontractors:

John H. Parry, Tiles
Grueby Faience Company, Faience

Color Scheme:

Blue tile tablets
Light blue tile bands
Blue/green faience cornice
Multi-color faience plaques

Platform Extensions:

South end of both platforms

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137th Street and Broadway

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Silver/blue tile tablet (this may be a replacement)
White tile bands
Buff terra cotta cornice
Green terra cotta plaques

Platform Extensions:

South ends of both platforms

145th Street and Broadway

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue tile tablets
Blue tile bands
White terra cotta cornice
Light blue terra cotta plaques

Platform Extensions:

South end of uptown platform, north end of downtown

157th Street

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue/green tile tablets
Buff tile bands
Green terra cotta cornice
Buff terra cotta plaques

Platform Extensions:

North ends of both platforms

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181st Street

Material Subcontractor:
Alfred Boote Company, Tiles

Color Scheme:
Blue tile tablets
Multi-color tile bands
Light buff brick
Marble trim

Platform Extensions:
North ends of both platforms

This is also deep tunnel. The original elevator shaft and stairway are on the east wall, and the new elevator has been inserted on the same wall.

191st Street

This station was not part of the original contract. It was opened January 14, 1911, and resembles the extensions of 168th and 181st Streets in appearance.

110th Street and Lenox Avenue

Material Subcontractor:
John H. Parry, Tiles

Color Scheme:
Blue/green tile panels, no terra cotta or faience
Green, buff tile bands

116th Street and Lenox Avenue

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:
Blue tile tablets
Buff tile bands
Light blue terra cotta cornice
Dark blue terra cotta plaques

Platform Extensions:
Small extensions on north ends of both platforms

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125th Street and Lenox Avenue

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue tile tablets
Pink tile bands
Green terra cotta cornice
Dark blue terra cotta plaques

Platform Extensions:

Small extensions on north ends of both platforms

135th Street and Lenox Avenue

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue/green tile tablets
Violet tile bands
White terra cotta cornice
Green terra cotta plaques

Platform Extensions:

Small extensions on north ends of both platforms
Original ticket booth on downtown control area

145th Street and Lenox Avenue

Material Subcontractors:

Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:

Blue/green tile tablets
Buff tile bands
Buff terra cotta cornice
Green terra cotta plaques

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Mott Avenue (now 149th Street and Grand Concourse)

Material Subcontractor:
John H. Parry, Tiles

Color Scheme:
Multi-color tile work, no terra cotta or faience

This station has been drastically altered by its connection
with the Contract Three Lexington Avenue line

North Third Avenue

Material Subcontractors:
Manhattan Glass Tile Company, Tiles
Atlantic Terra Cotta Company, Terra Cotta

Color Scheme:
Blue tile tablets
Green tile bands
Light blue terra cotta cornice
Dark blue terra cotta plaques

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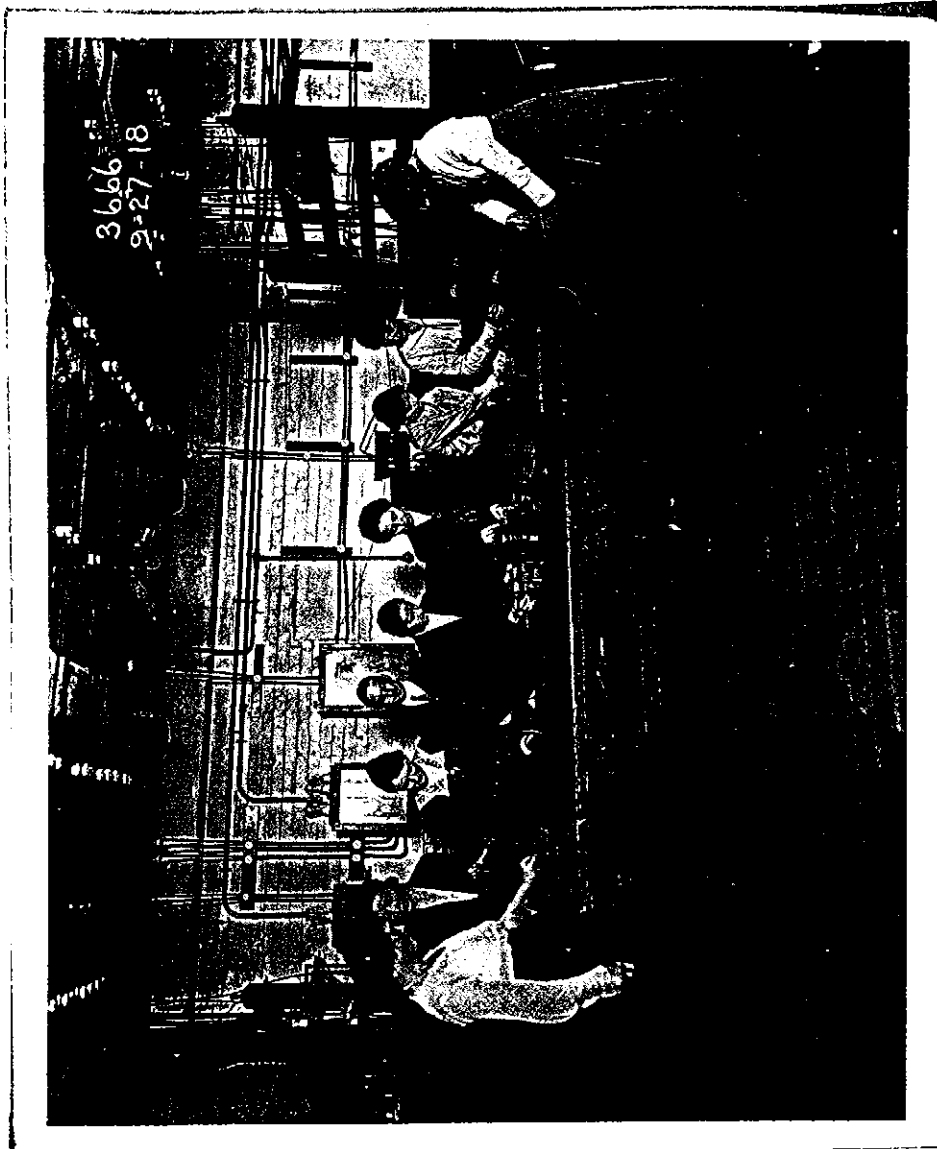
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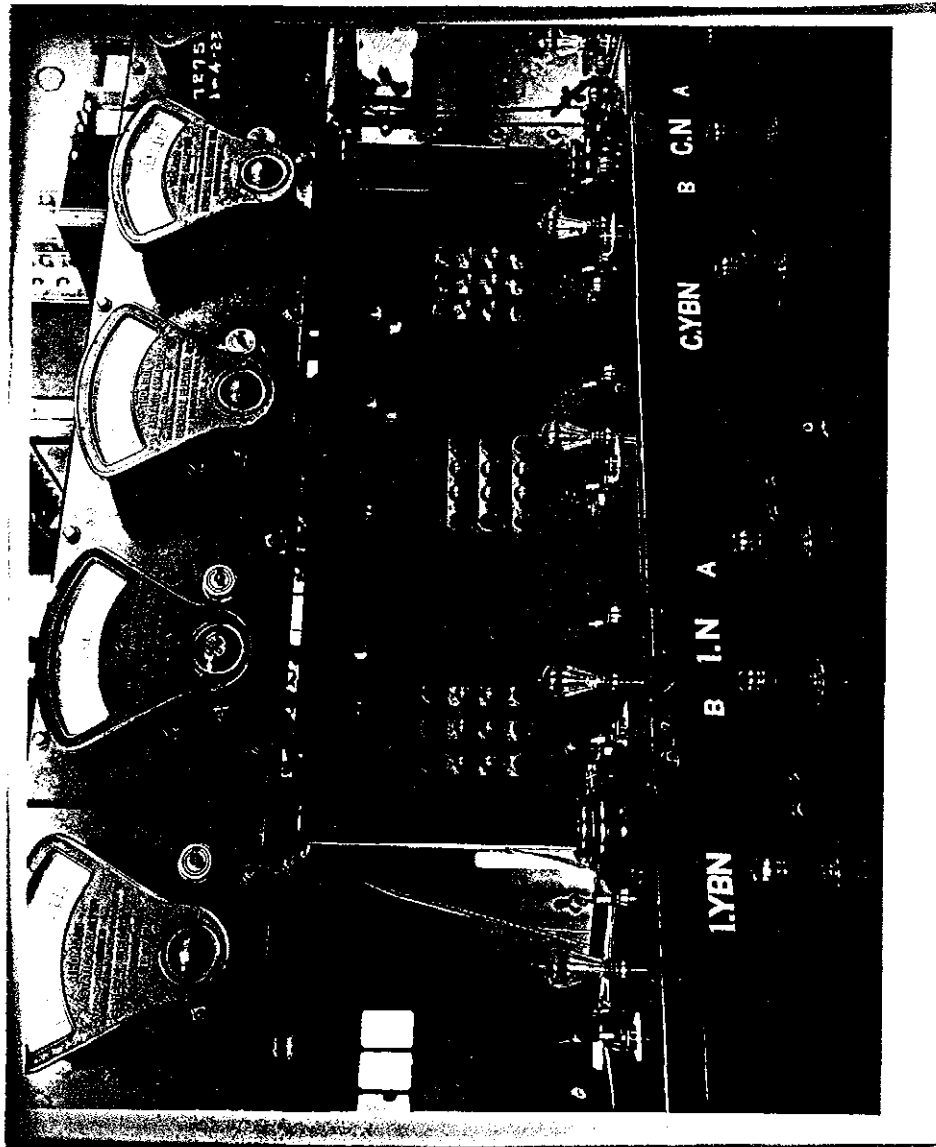
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Angeles, 1956).



Photocopied courtesy of the New York City Metropolitan Transit Authority.

1 Photocopied August 1978. (MTA)



Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
UNIDENTIFIED SUB-STATION, c.1923. GENERAL ELECTRIC
CONTROL PANEL MOUNTED ON IRON COLUMNS.



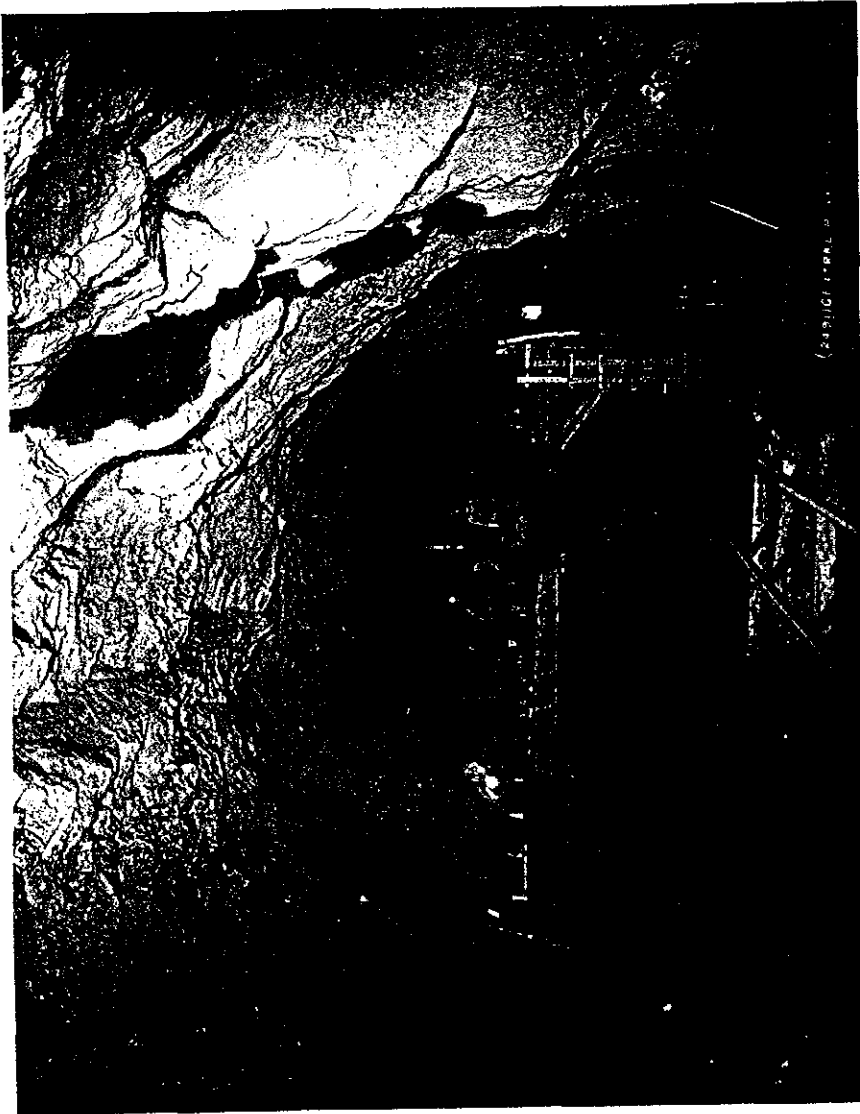
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
UNIDENTIFIED IRT SUBSTATION. NOTE THREE-FOOT SPACE
BETWEEN CONTRL BOARD AND INSTRUMENT PANEL, GIVING
VIEW OF THE OPERATING FLOOR.



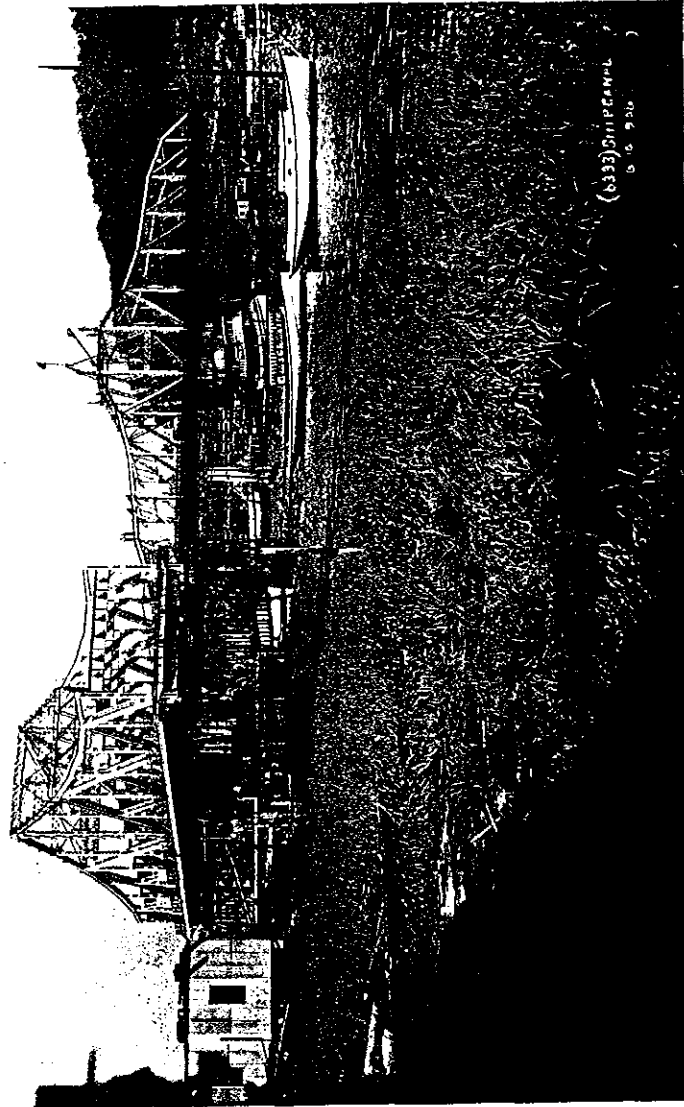
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602, Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
TRAVELING FORMS USED TO CENTER CONCRETE ARCH IN LINING
ROCK TUNNEL AT CENTRAL PARK. NOTE COMPLETED CON-
CRETE SIDEWALLS AT LOWER LEFT AND RIGHT; ALSO NOTE
RAILS AT BASE OF TRAVELER UPON WHICH DEVICE MOVES.
DECEMBER 8, 1902.



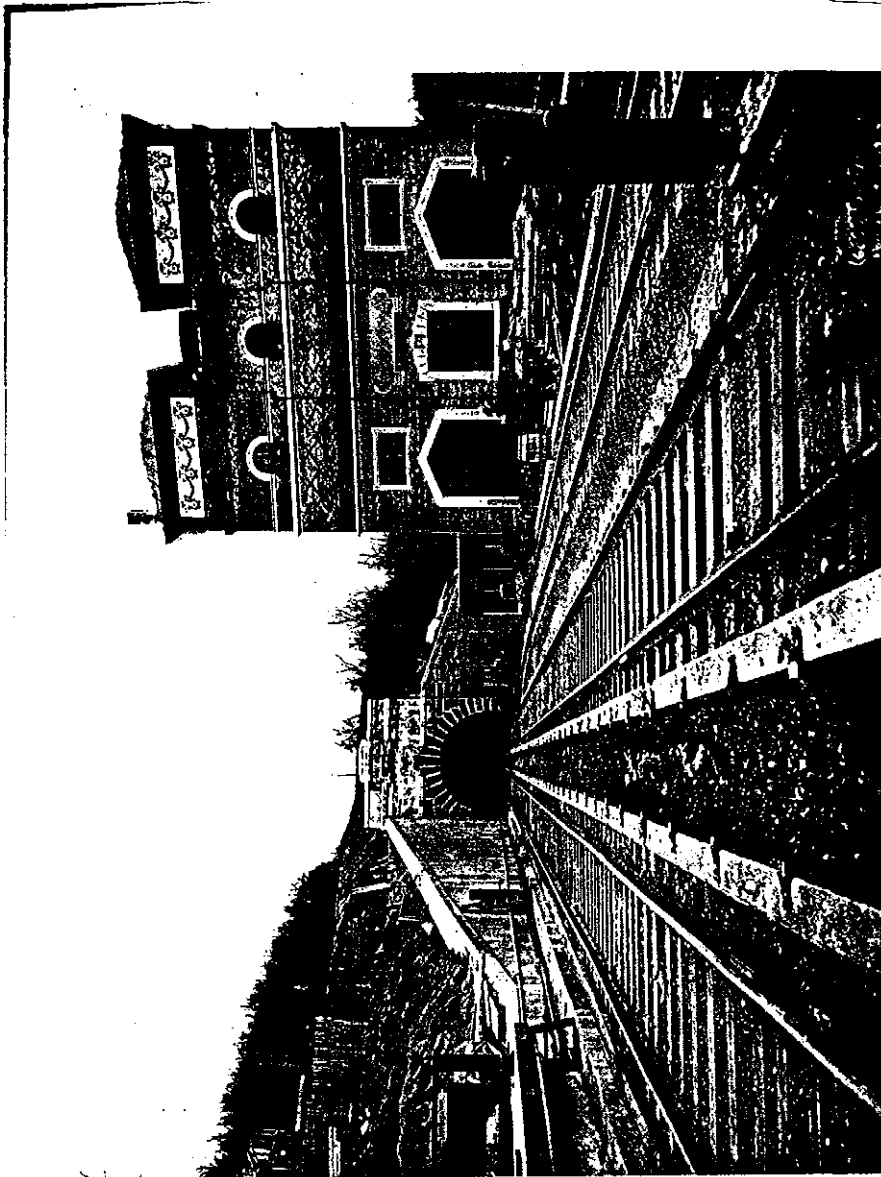
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING TRAVELING PLATFORM USED TO FORM SIDEWALLS
IN CONCRETE-LINED TUNNEL BENEATH CENTRAL PARK.



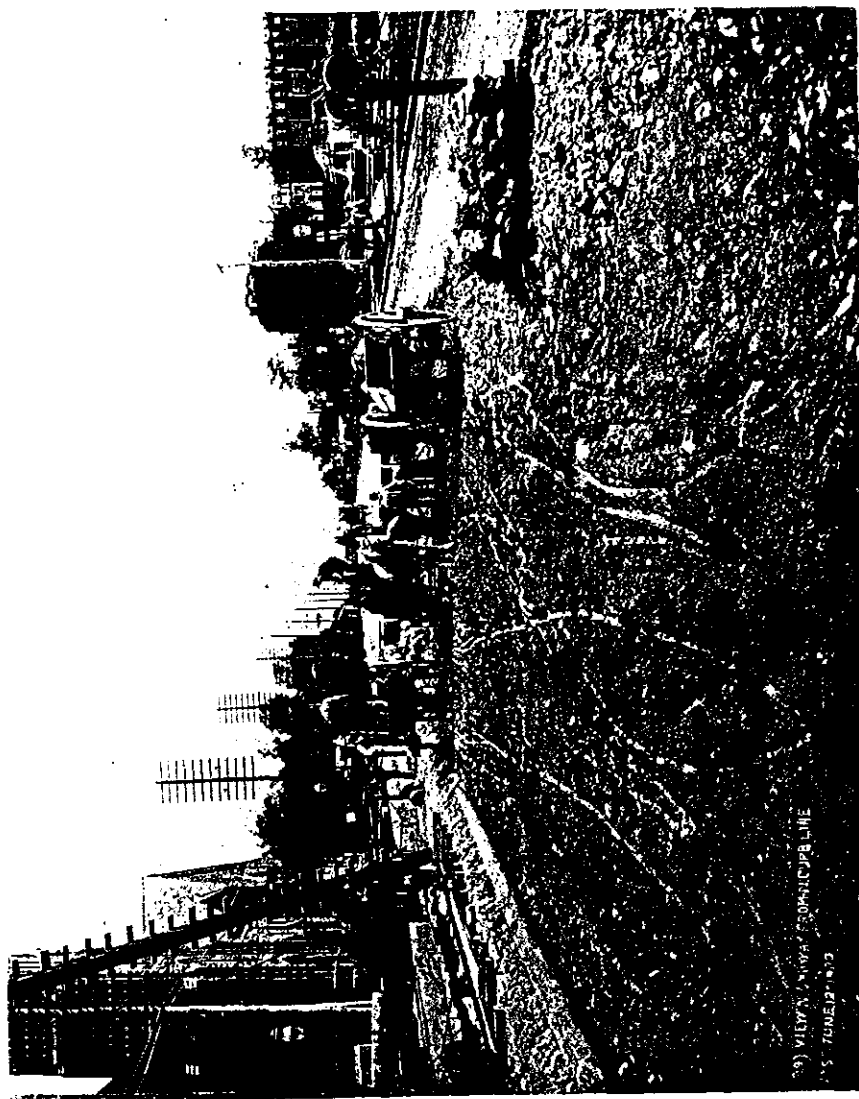
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
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Photocopied August 1978. (A)
VIEW SHOWING THE REMOVAL OF ORIGINAL HARLEM SHIP CANAL
SWINGING BRIDGE (RIGHT); WHILE THE NEW BRIDGE, BUILT
ON FALSEWORK OVER THE RIVER (LEFT) AWAITS THE BARGES
NEEDED TO FLOAT IT INTO POSITION. JUNE 14, 1906.



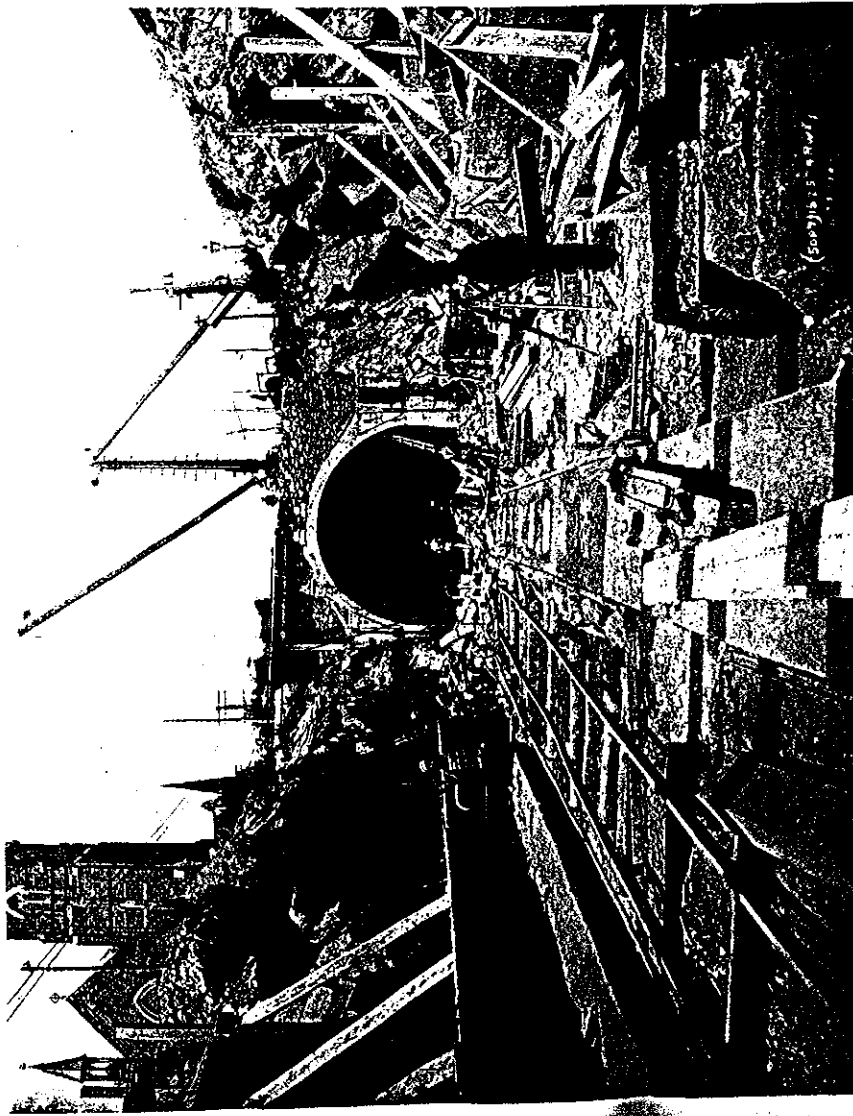
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
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Photocopied August 1978. (A)
VIEW SHOWING FORT GEORGE TUNNEL PORTAL AND ELECTRICAL
SUBSTATION #17, HILLSIDE AVENUE. MARCH 9, 1906.



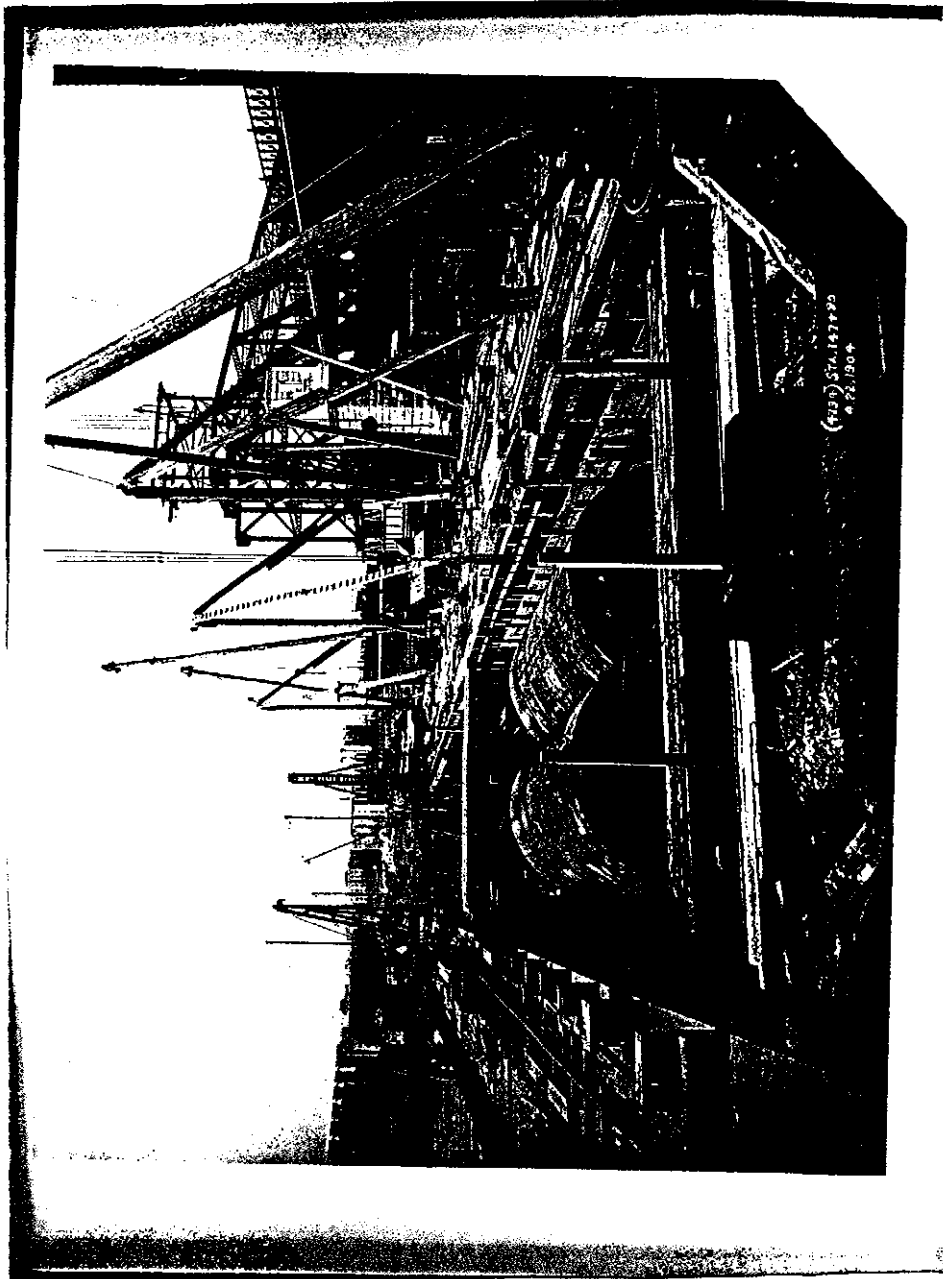
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW LOOKING NORTH ON BROADWAY AT 157TH STREET;
BEGINNING OF EXCAVATION. JUNE 12, 1900.



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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING EXCAVATION AND SURVEYING WORK AT 157TH
STREET STATION AT BROADWAY. JUNE 24, 1904.



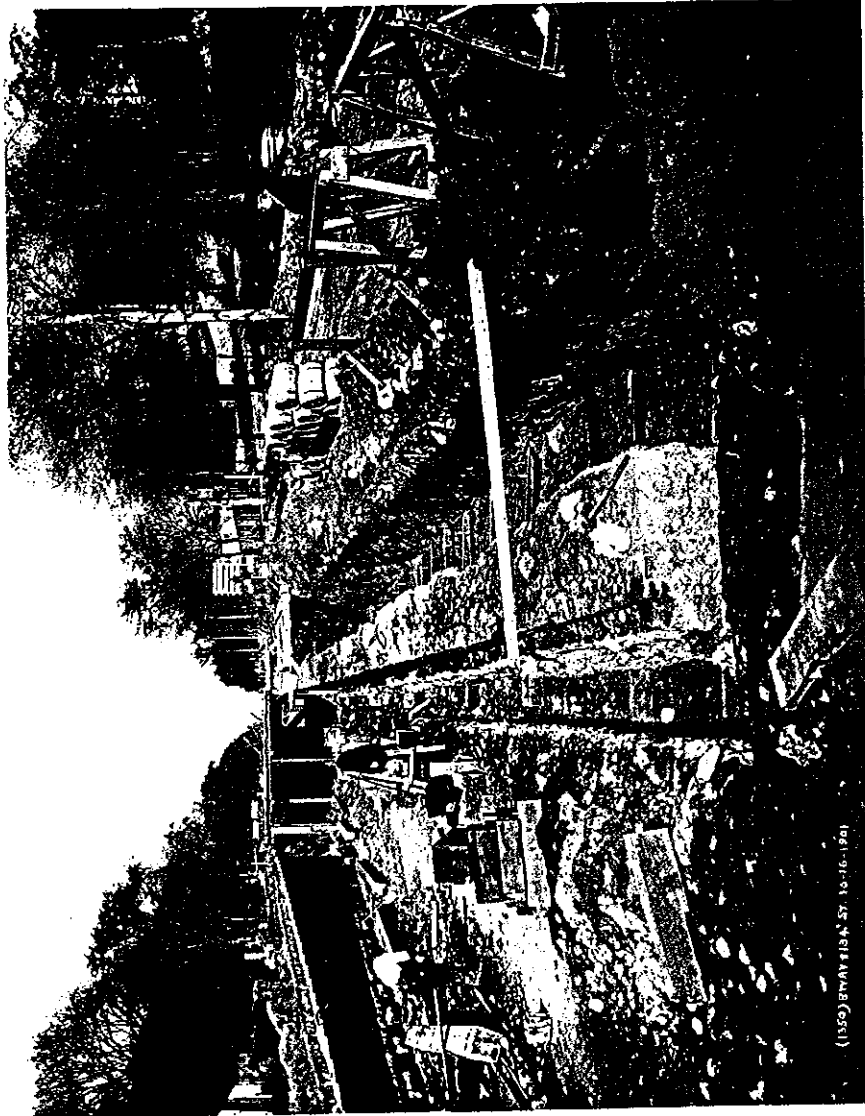
Photocopy of photograph from the collection of Hugh A. Durne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING ERECTION OF CAST IRON LINING FOR HARLEM
RIVER TUNNEL PRIOR TO BEING FLOATED INTO POSITION AND
SUNK.



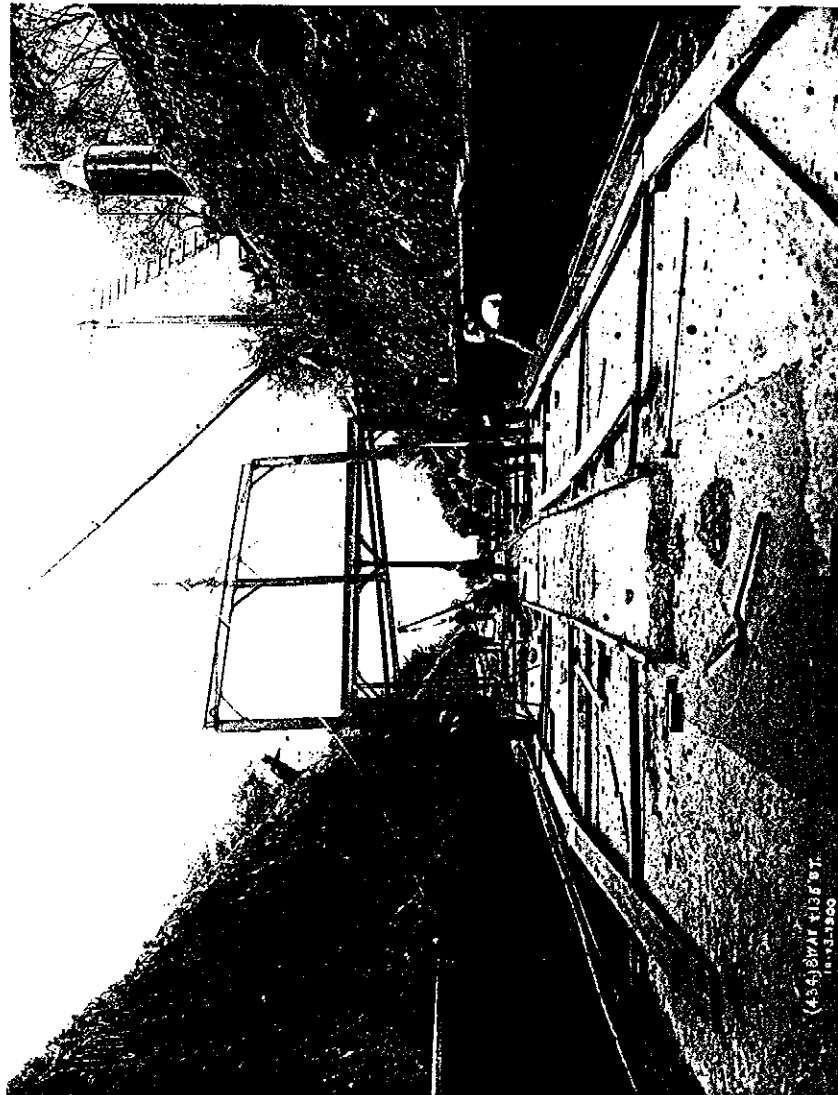
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING TEMPORARY STEEL UNDERPINNING OF COLUMBUS
MONUMENT DURING CONSTRUCTION OF SUBWAY. MAY 8, 1901.



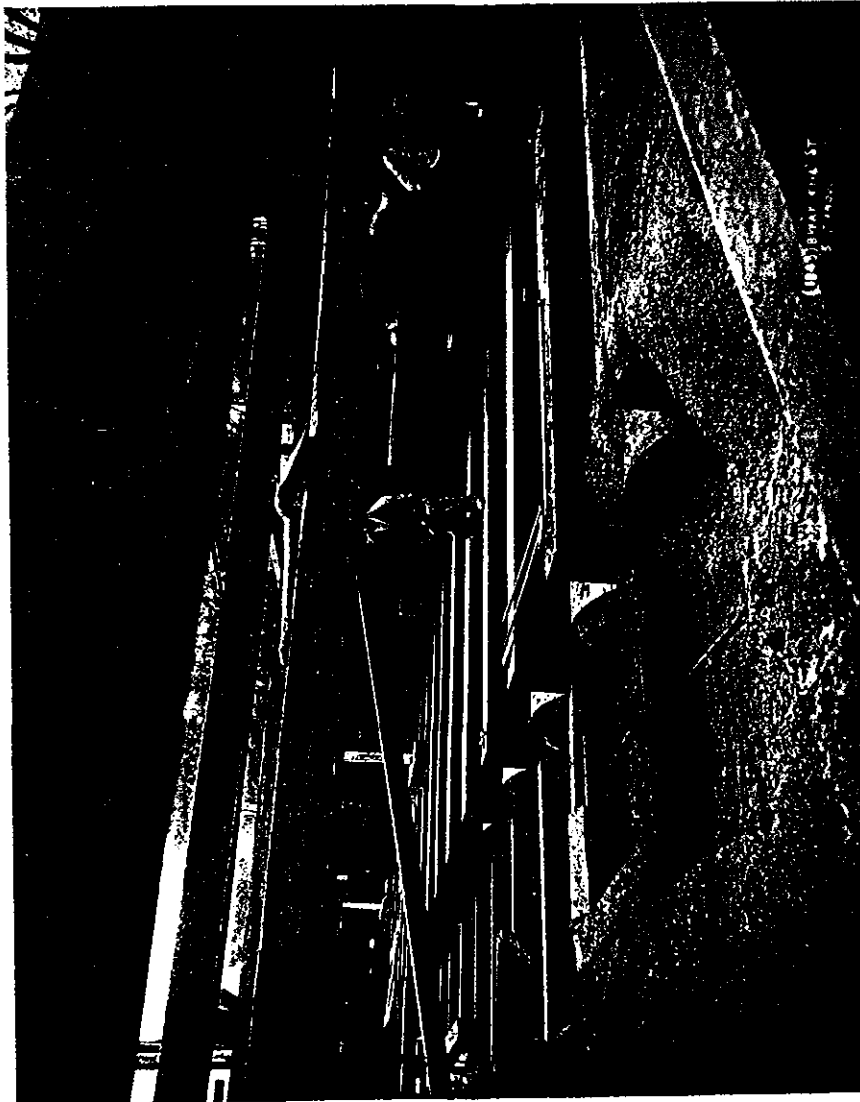
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602, Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
CONSTRUCTION AT BROADWAY AND 134TH STREET, WHERE CON-
CRETE RETAINING WALLS ARE BEING ROLLED BACK TO ACCOMO-
DATE EXPANSION OF LINE FROM TWO TO THREE TRACKS.
OCTOBER 16, 1901.



Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EXCAVATION AND ERECTION AT BROADWAY AND 135TH STREET
OF FIRST STEEL BENT FRAME. OCTOBER 13, 1900.



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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING STEEL AND CONCRETE WORK AT BROADWAY AND
114TH STREET. NOTE FORMS FOR CONCRETE ROOF ARCHES
PLACED BETWEEN COLUMNS AND GIRDERS. MAY 7, 1902.



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Photocopied August 1978. (A)
REINFORCED CONCRETE ROOF CONSTRUCTION USED BENEATH
LENOX AVENUE. NOVEMBER 24, 1902.



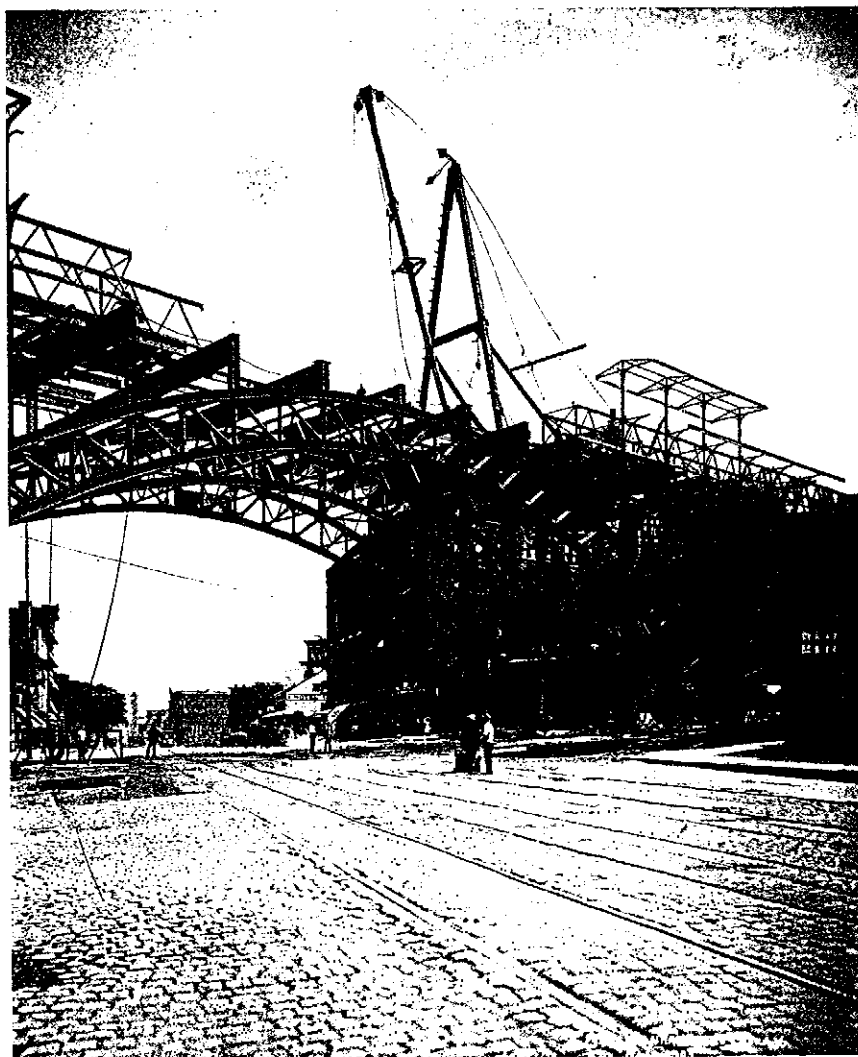
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EAST WALL AND ROOF ALREADY MOVED AND WEST WALL BEING
PREPARED FOR MOVEMENT, 135TH STREET. NOVEMBER 19, 1901.



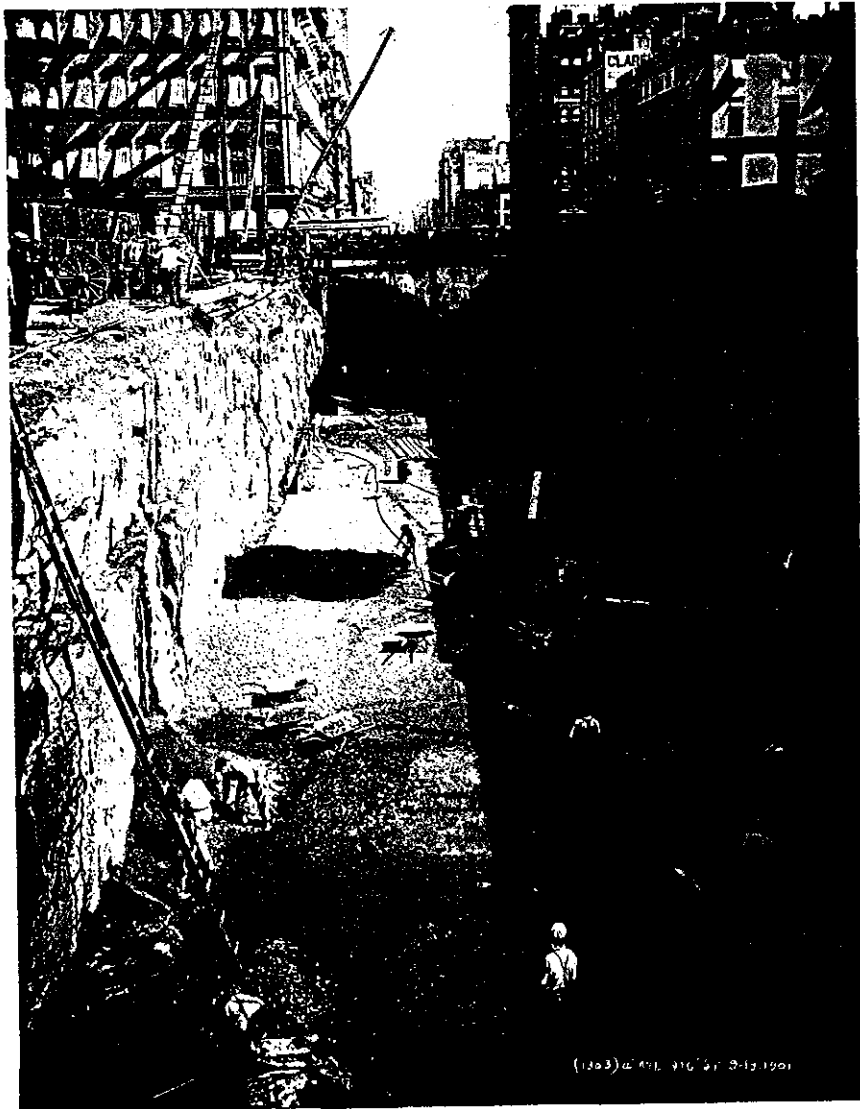
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
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Photocopied August 1978. (A)
STRUCTURAL STEEL WORK AT FORT GEORGE, BEGINNING OF
ELEVATED PORTION IN MANHATTAN. APRIL 26, 1904.



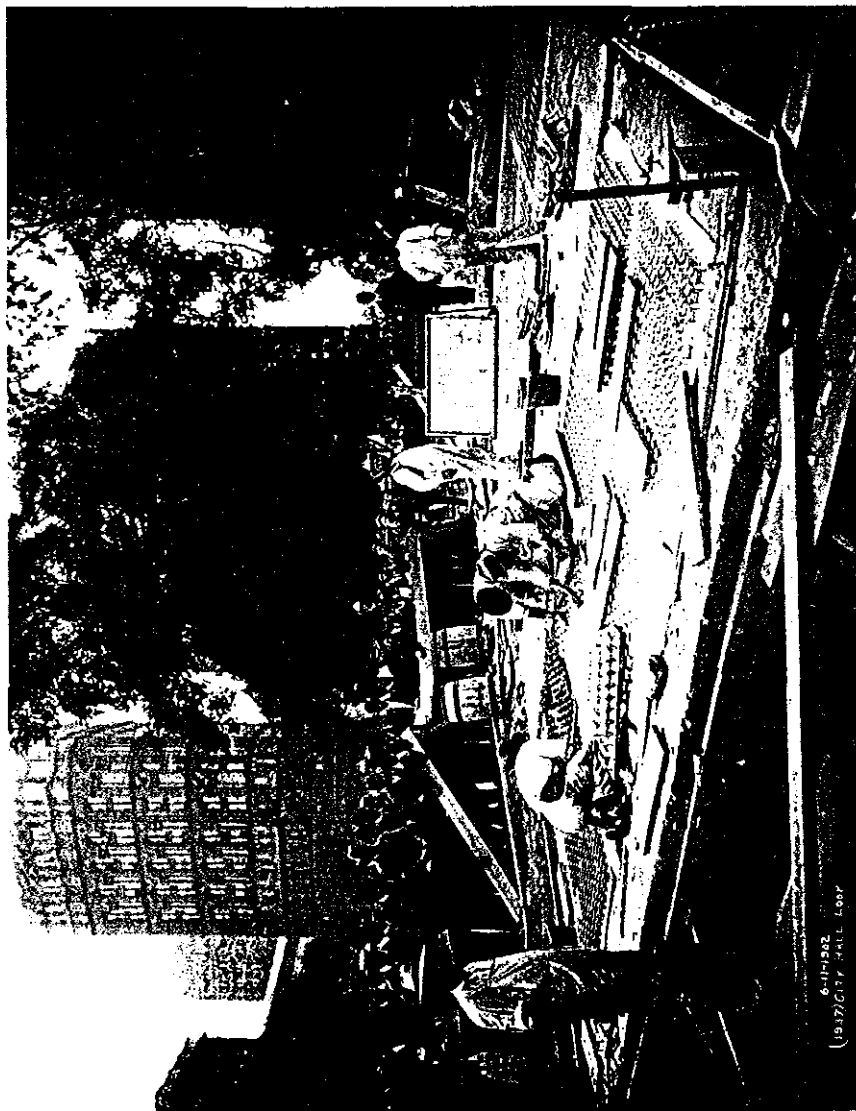
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
ERECTION OF STEEL-ARCH BRIDGE AT MANHATTAN STREET AND
BROADWAY. 1903.



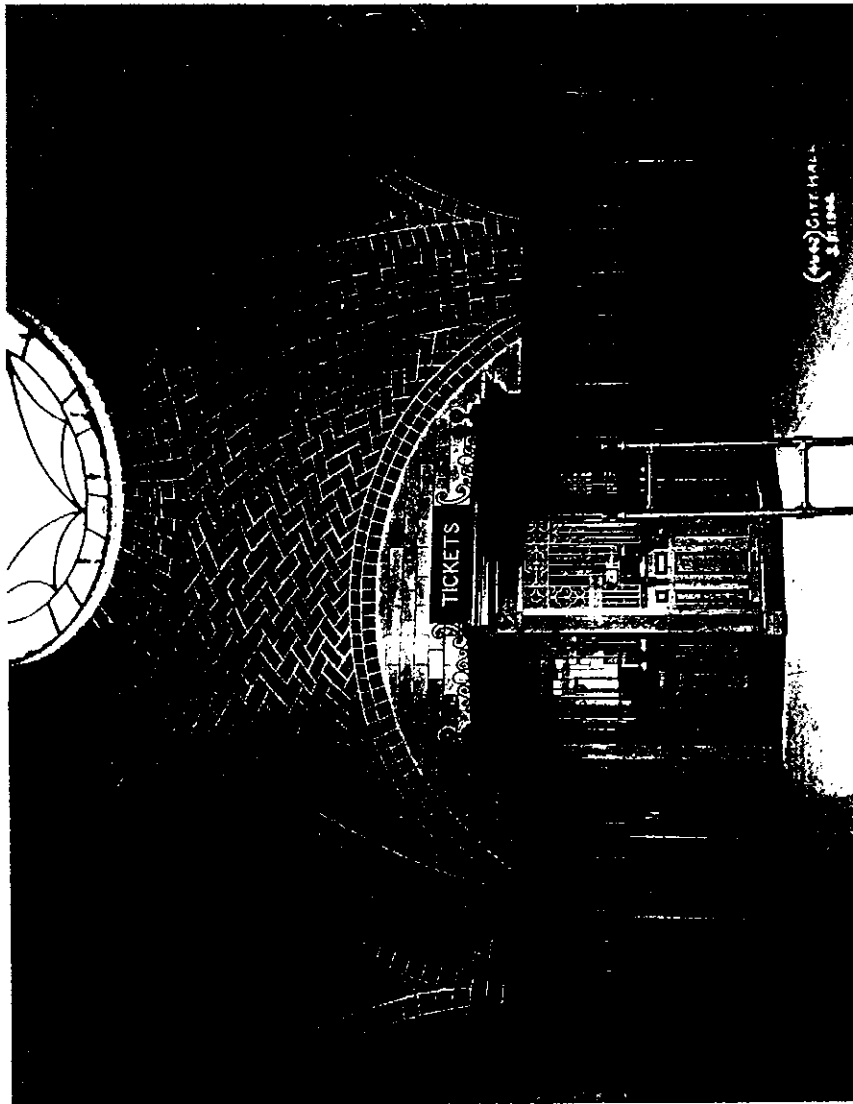
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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EXCAVATION AT 4TH AVENUE AND 16TH STREET, LAYING OF
CONCRETE FLOOR. SEPTEMBER 13, 1901.



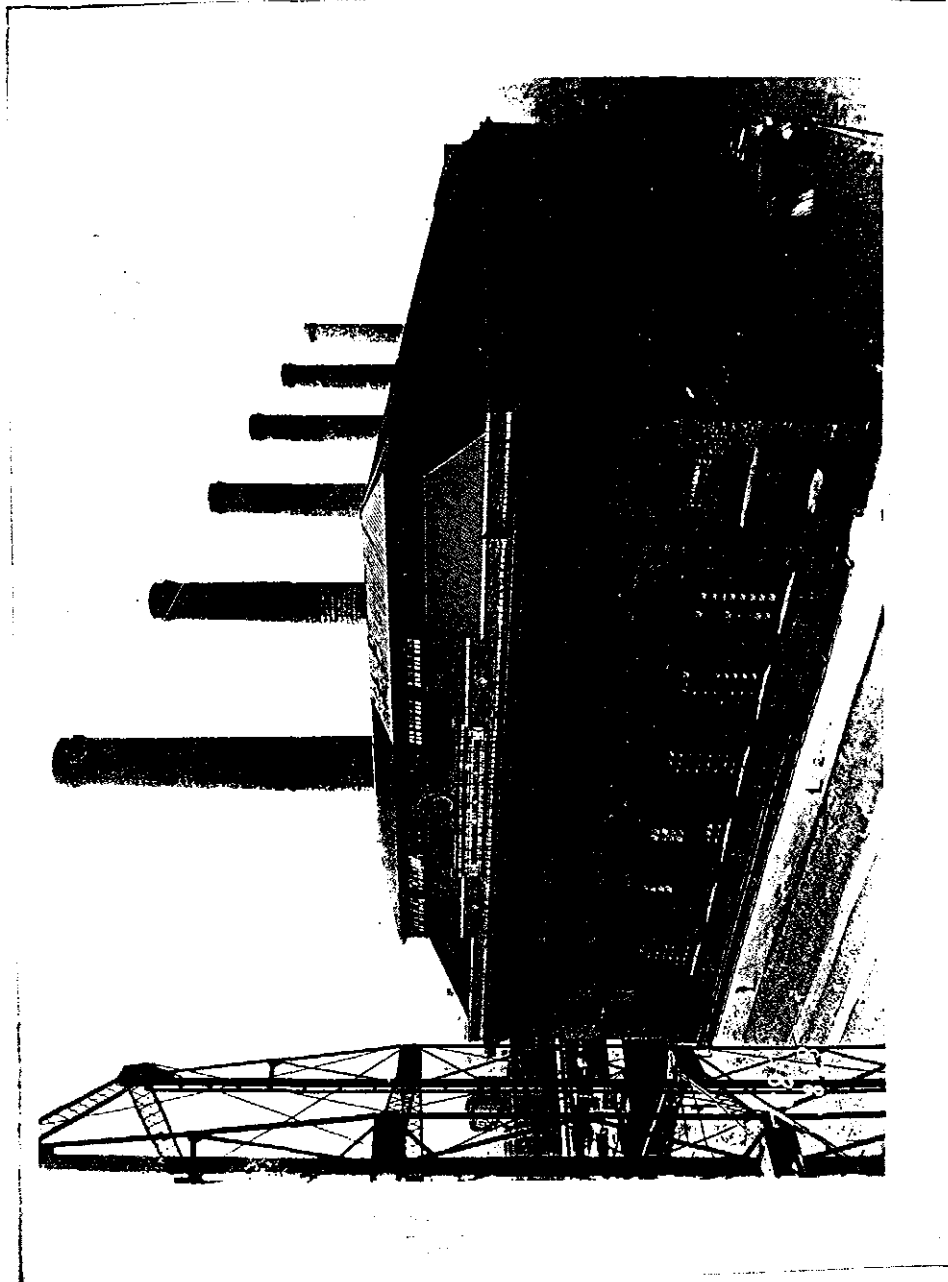
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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A) JUNE 11, 1902.
CONSTRUCTION OF VAULT LIGHTS AT CITY HALL LOOP.



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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
TICKET BOOTH IN CITY HALL STATION. MARCH 31, 1904.



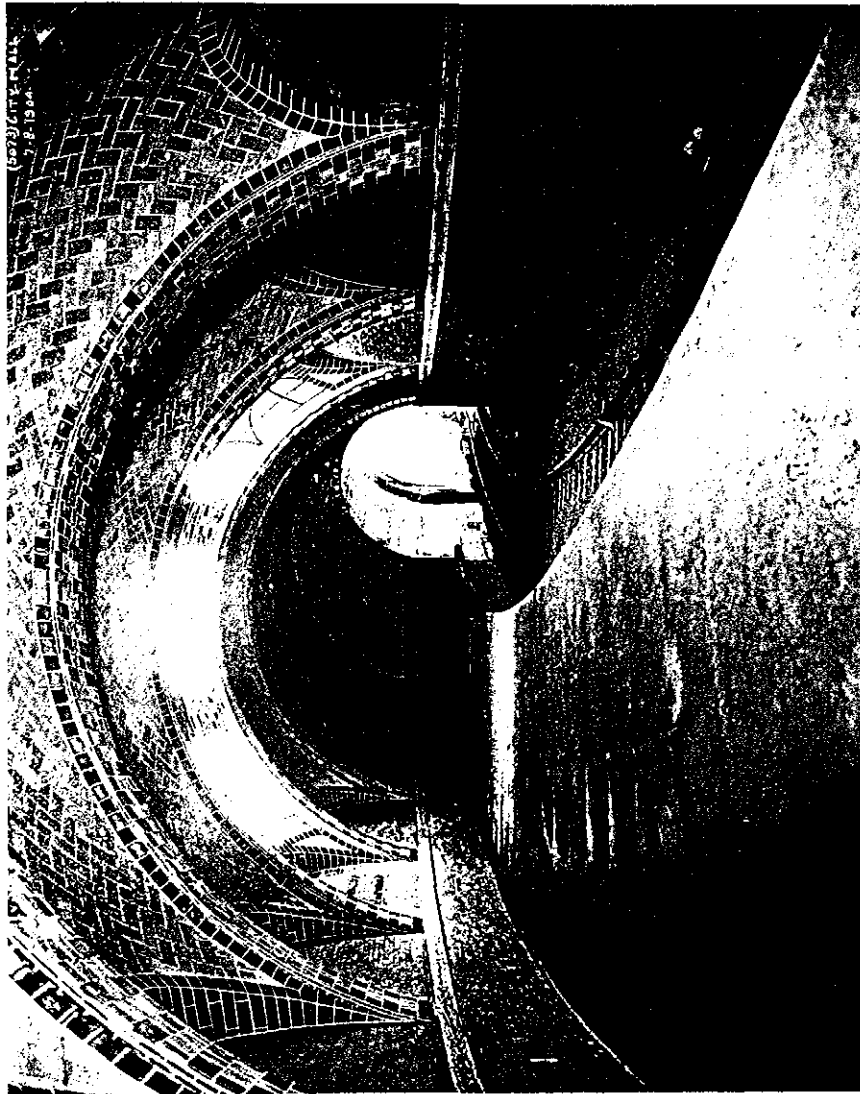
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW OF EXTERIOR OF IRT POWERHOUSE. SEPTEMBER 23, 192



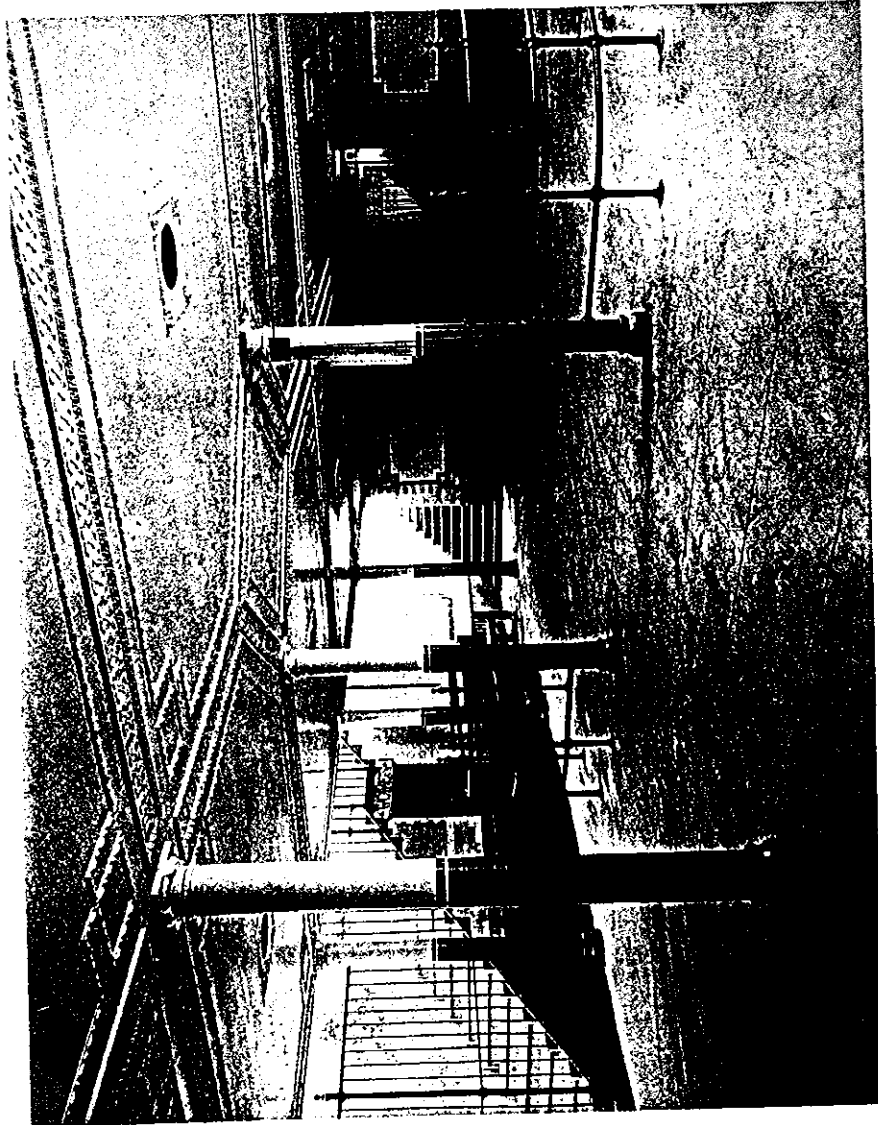
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FALSEWORK AND ARCH CONSTRUCTION AT CITY HALL LOOP.
FEBRUARY 22, 1902.



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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
STATION PLATFORM AND ARCHES AT CITY HALL. JULY 8, 190



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Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
DOWNTOWN STATION AT 28TH STREET STOP.



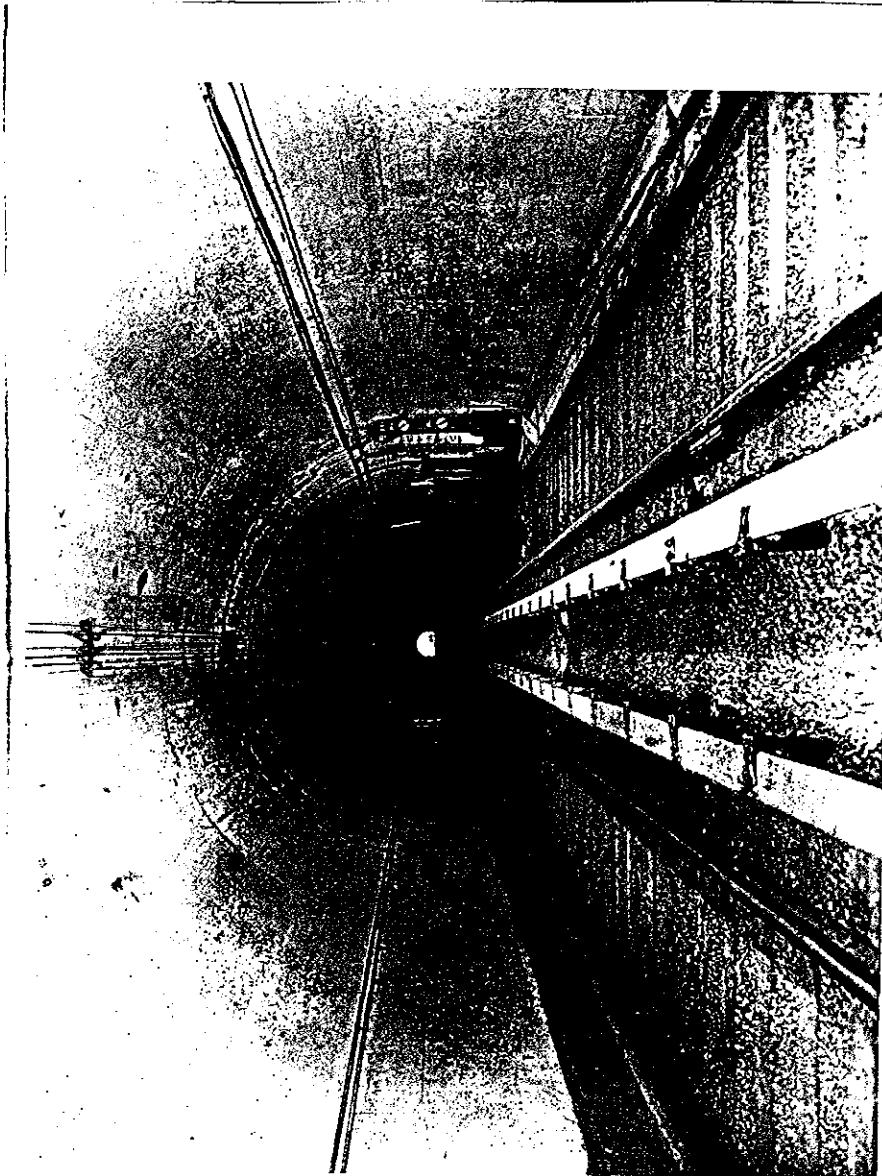
Photocopied August 1978, courtesy of the New York
City Landmarks Preservation Commission.
116TH STREET STATION ON BROADWAY DURING DISMAN-
TLING. C.1970.



EXTERIOR OF SUB-STATION.

Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EXTERIOR VIEW OF SUBSTATION #11, AT CITY HALL PLACE
BETWEEN DUANE AND PEARL STREETS. (DEMOLISHED)



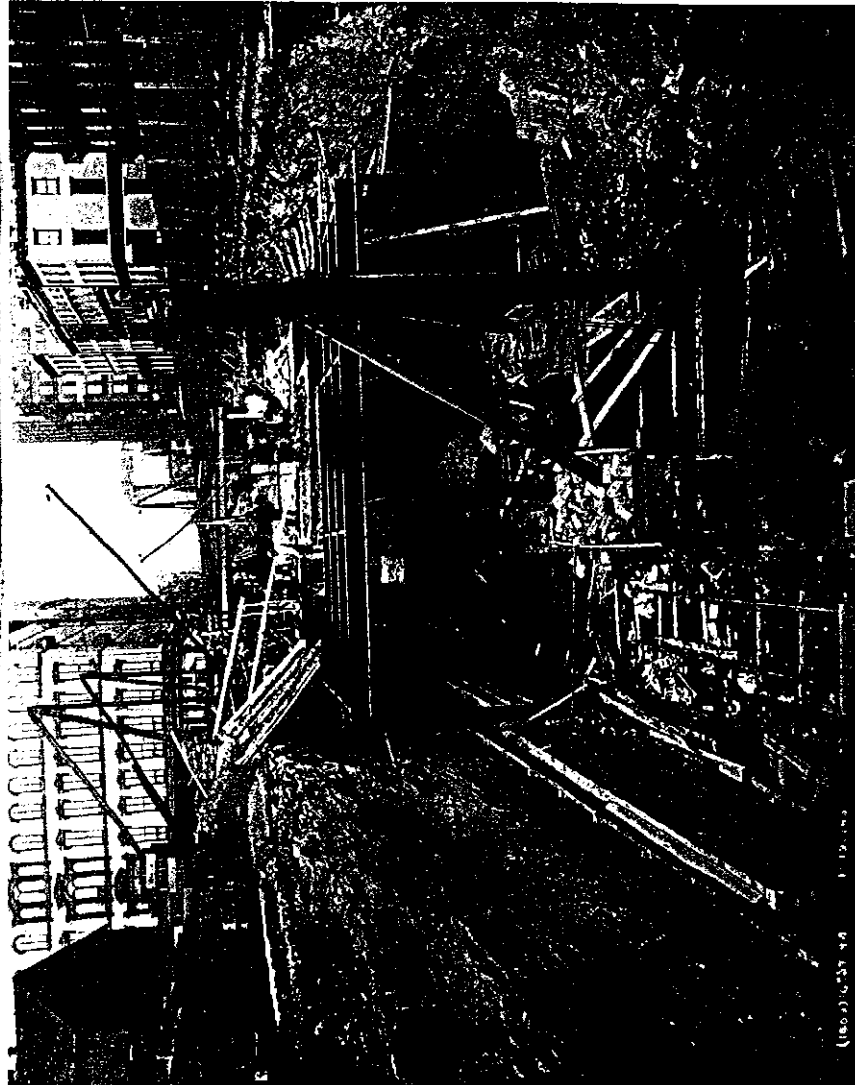
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
VIEW SHOWING COMPLETED PORTION OF TWO-TRACK,
CONCRETE-LINED, ARCH TUNNEL BENEATH 190TH STREET.
MARCH 9, 1906.



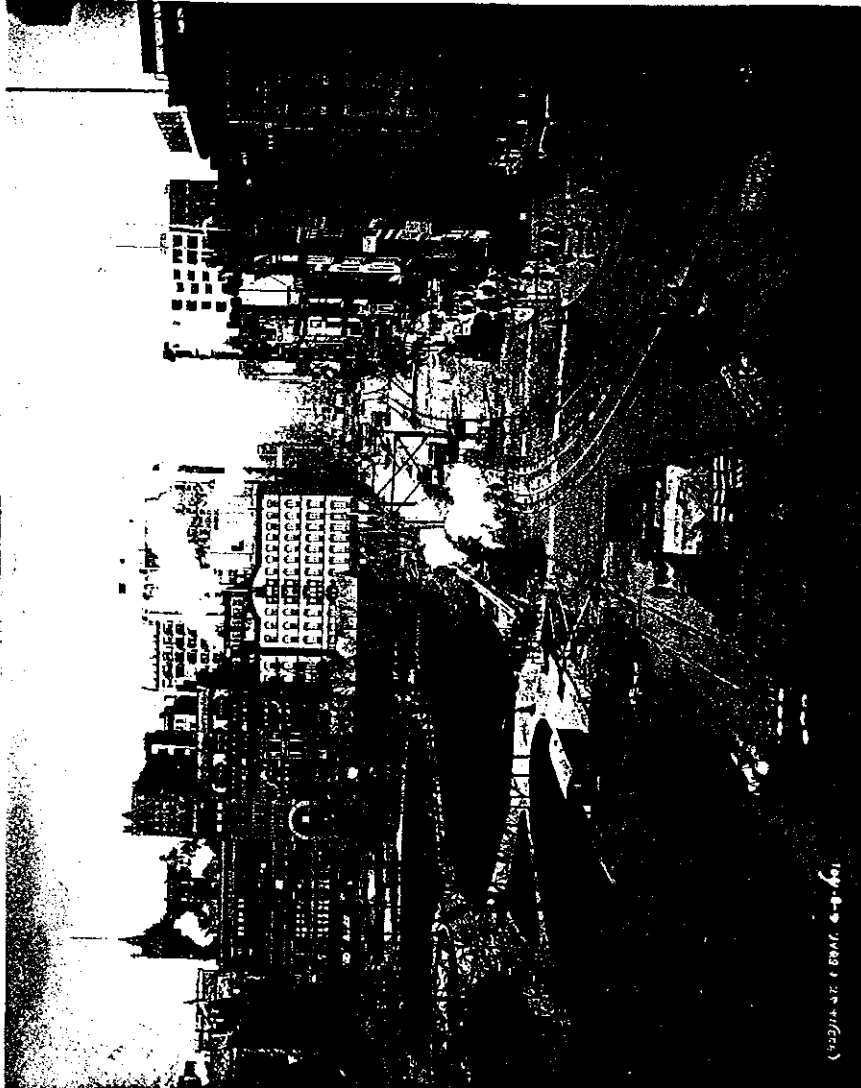
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Photocopied August 1978. (A)
WORKMEN LAYING WATER-PROOFING MATERIAL ON SUBWAY
FLOOR AT 149TH STREET AND CORTLANDT AVENUE.
SEPTEMBER 23, 1902.



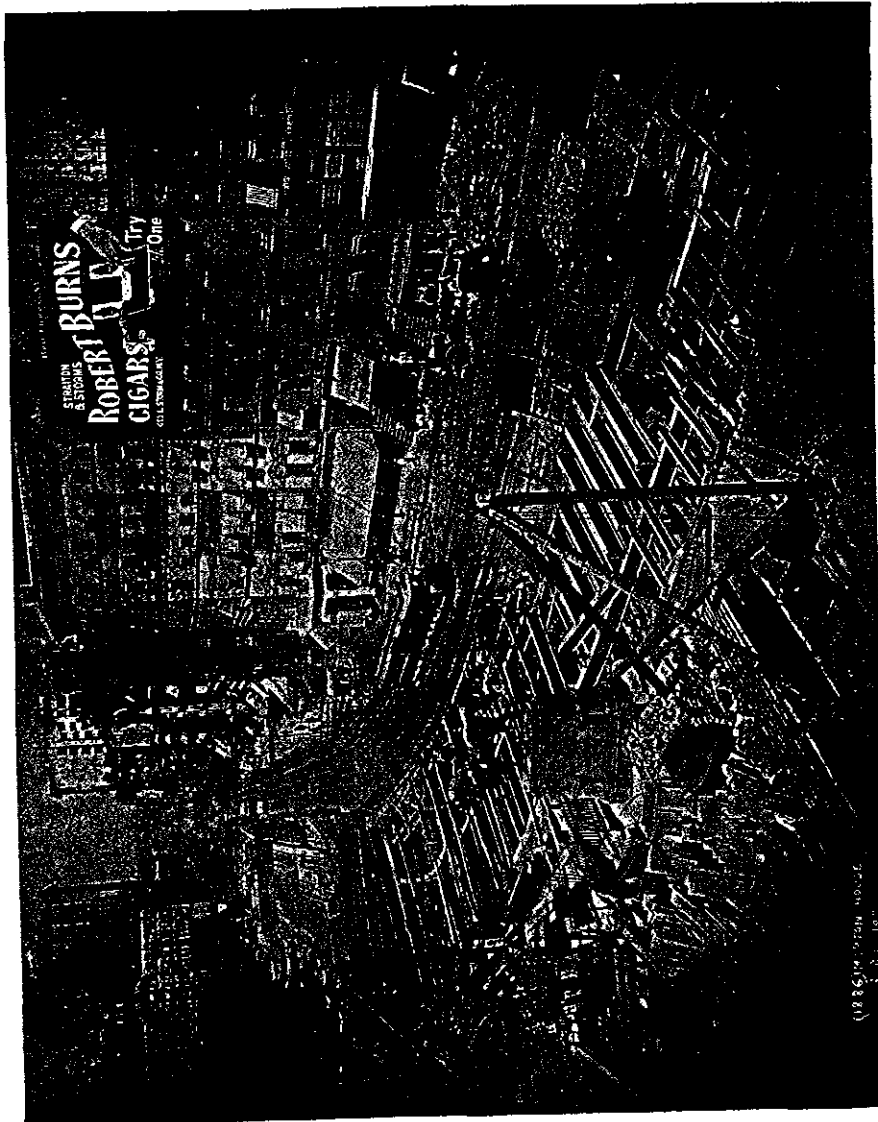
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

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EXCAVATION AND STEELWORK FOR THREE OF FOUR TRACKS
AT 16TH STREET AND 4TH AVENUE. NOVEMBER 13, 1901.



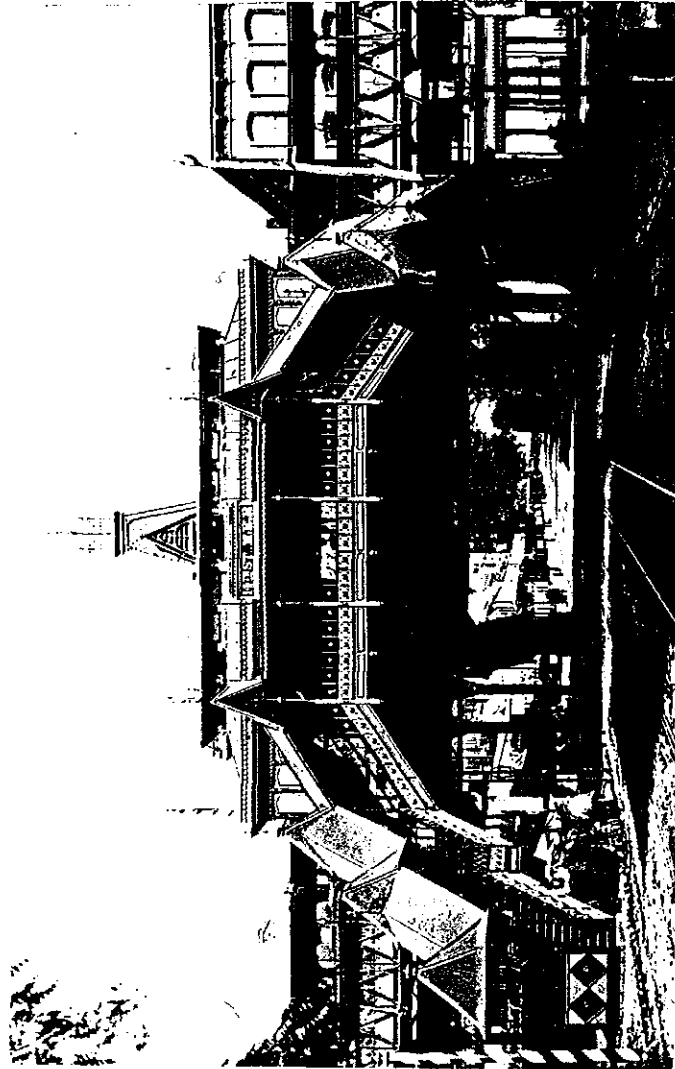
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
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Photocopied August 1978. (A)
STREETSCAPE AT 14TH STREET AND BROADWAY PRIOR TO
BEGINNING OF EXCAVATION, APRIL 5, 1901.



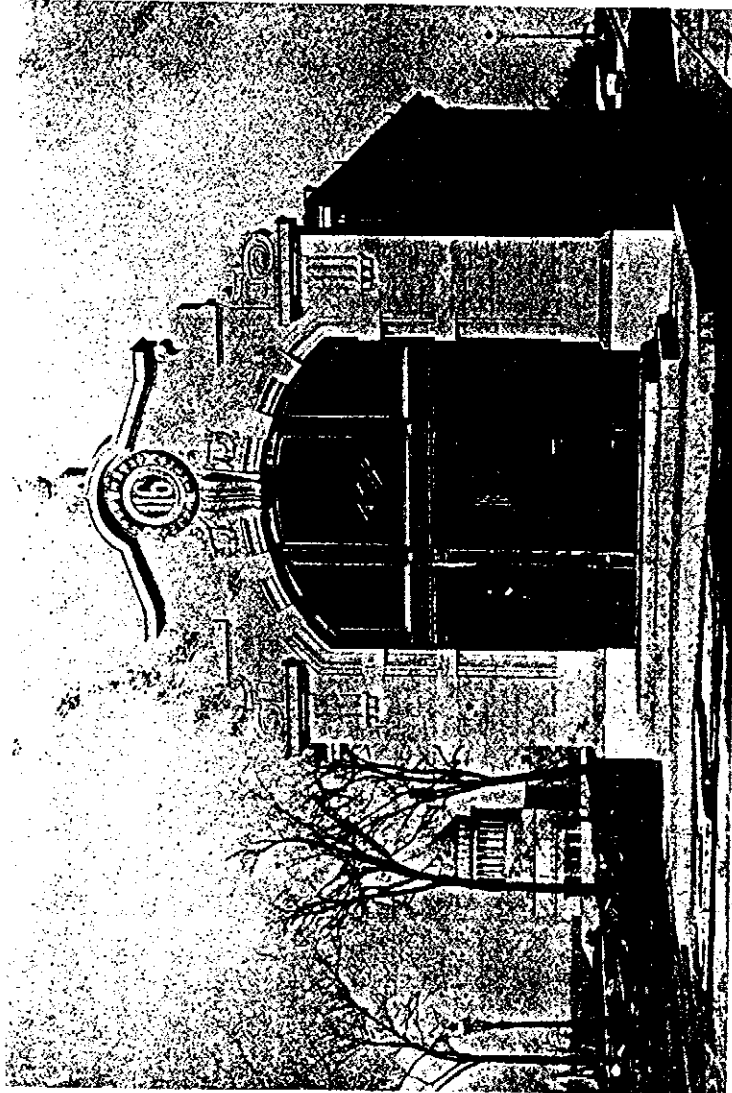
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EXCAVATION, STEELWORK FOR HALF OF SUBWAY, AND STREET-
SCAPE BY MORTON HOUSE (14TH STREET AND BROADWAY).
MAY 23, 1902.



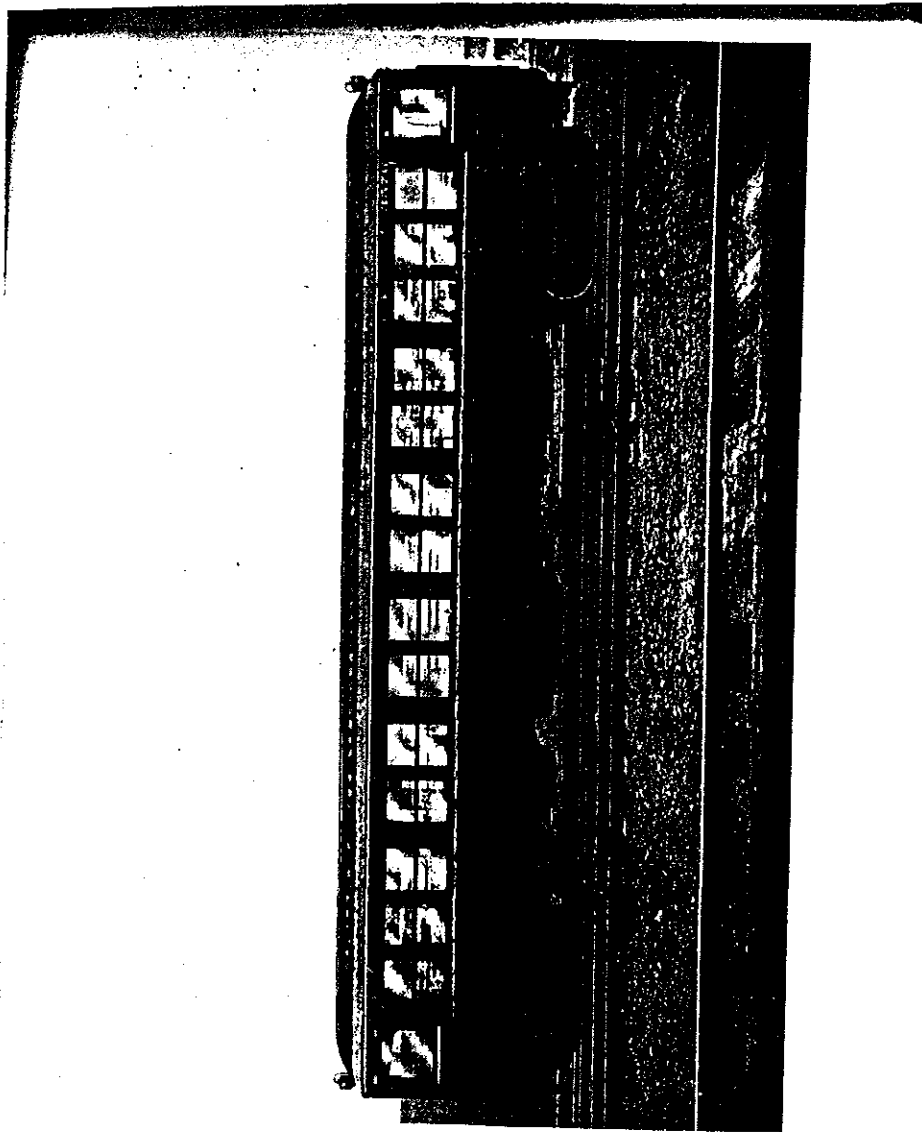
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Photocopied August 1978. (B)
14TH STREET M.E.R. STATION.



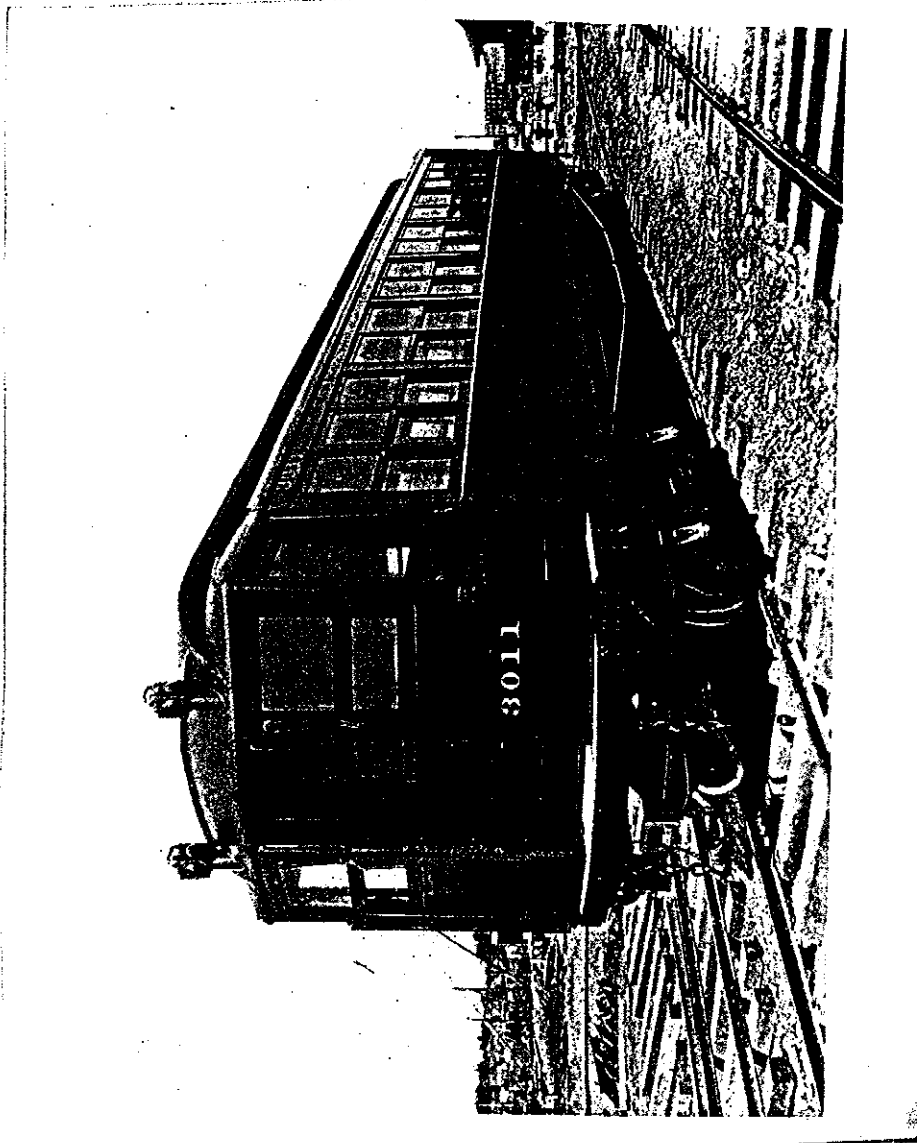
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116TH STREET STATION, C.1905.



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ALL-STEEL SUBWAY CAR ("GIBBS CAR"). MANUFACTURED BY
AMERICAN CAR & FOUNDRY COMPANY. VIEW TAKEN PRIOR
TO ADDITION OF CENTER DOOR.



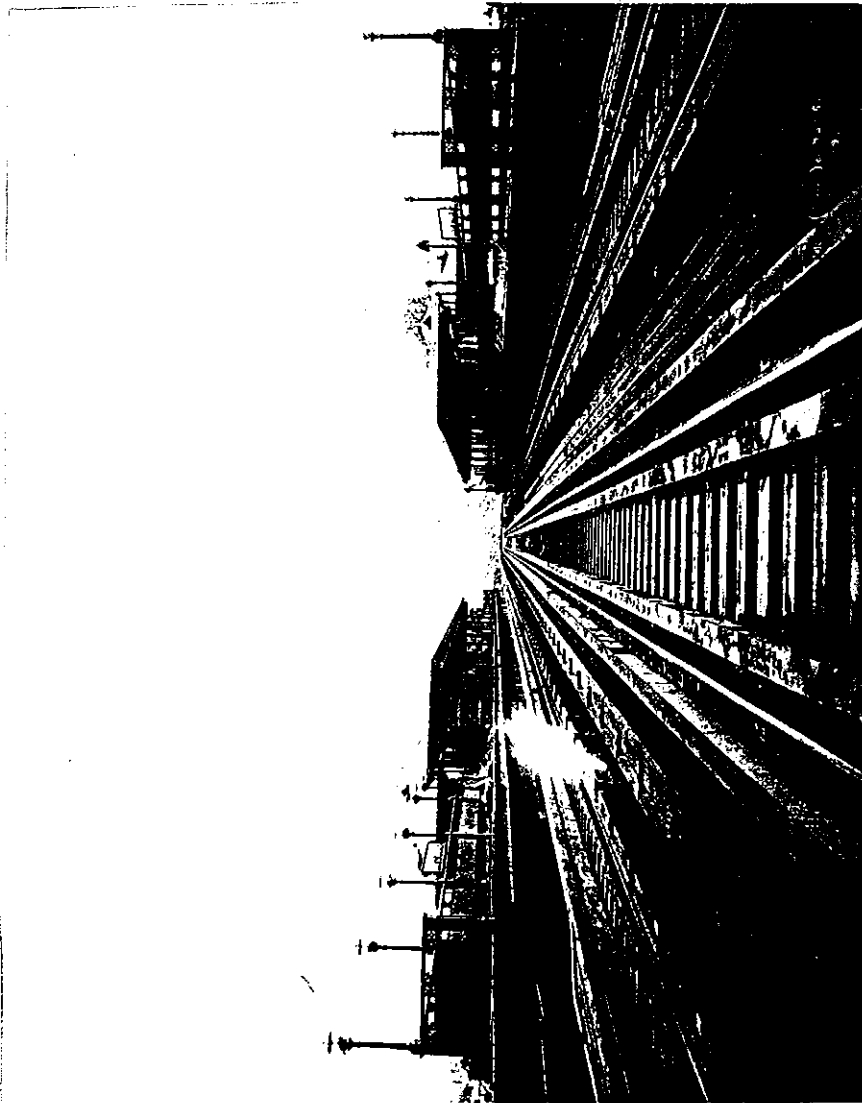
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Photocopied August 1978. (B)
COPPER-SIDED, WOODEN-FRAMED CAR OF THE TYPE FIRST
ORDERED FOR THE IRT. SUBSEQUENT CARS WERE STEEL-
FRAMED.



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PARTIALLY COMPLETED STATION AT BLEEKER & ELM STREETS.
MAY 27, 1903.



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VIEW SHOWING TRACKS AND PLATFORMS AT THE 207TH
STREET STATION. JULY 16, 1906.



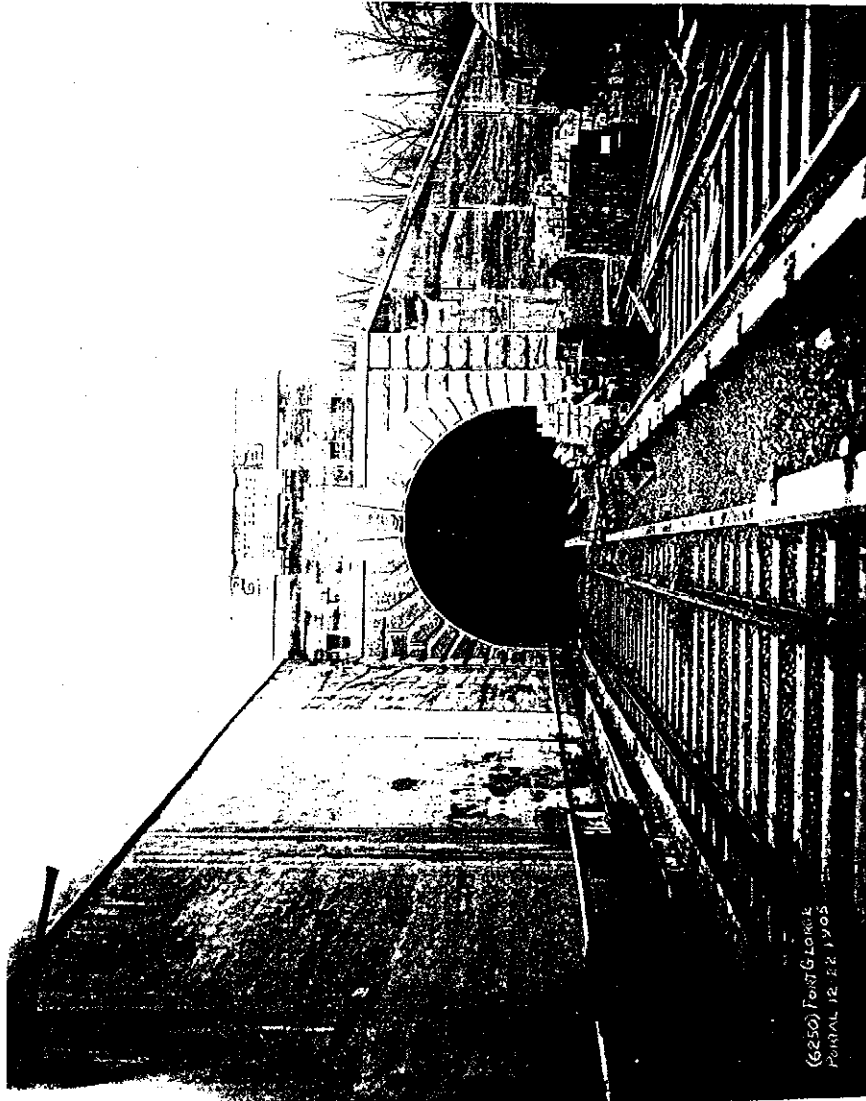
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LOUVERS. JUNE 18, 1906.



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ELEVATION OF 207TH STREET STATION. JULY 16, 1906.



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FORT GEORGE TUNNEL PORTAL. DECEMBER 22, 1905.



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ARCH CONSTRUCTION AT CITY HALL LOOP. FEBRUARY 22,
1902.



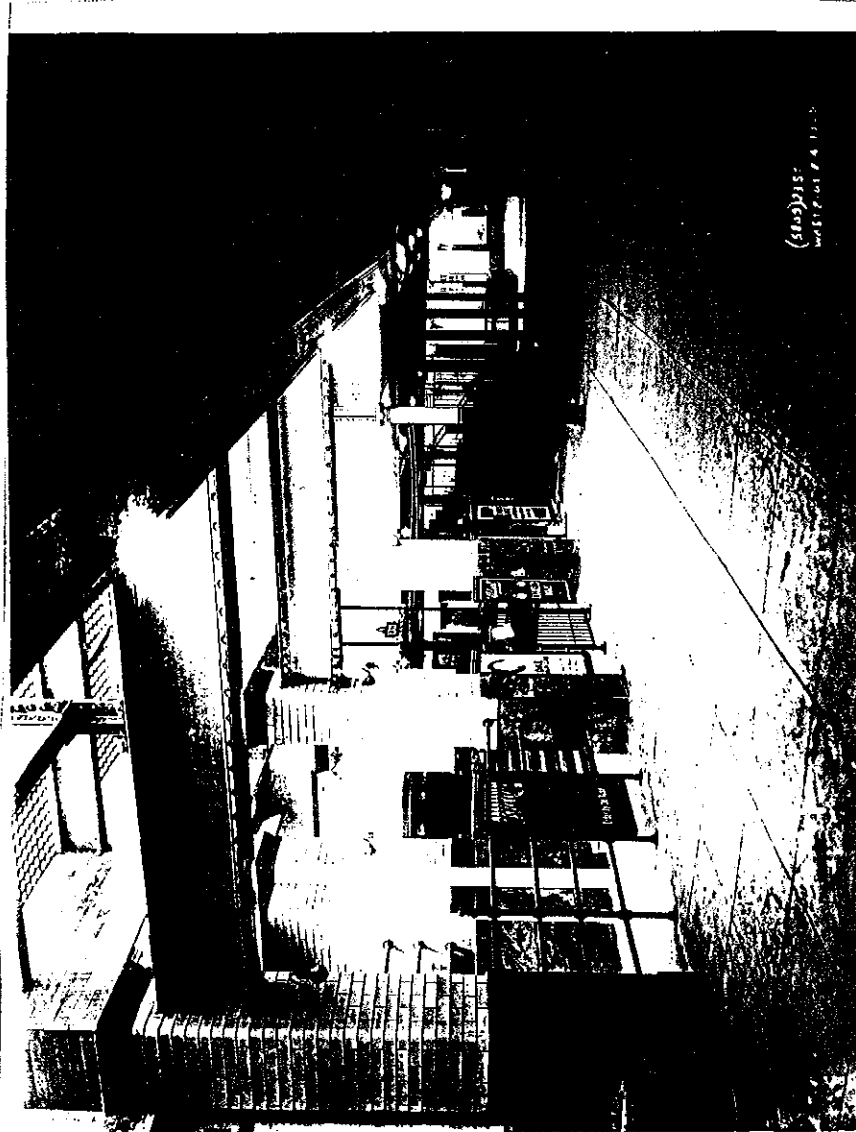
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Photocopied August 1978. (B)
ARCH-WORK AT PARTIALLY COMPLETED CITY HALL LOOP.
OCTOBER 7, 1902.



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STATION PLATFORM AT WORTH STREET. 1905.



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Photocopied August 1978. (B)
WEST-SIDE EXIT OF 23RD STREET STATION. FEBRUARY 4,
1905.



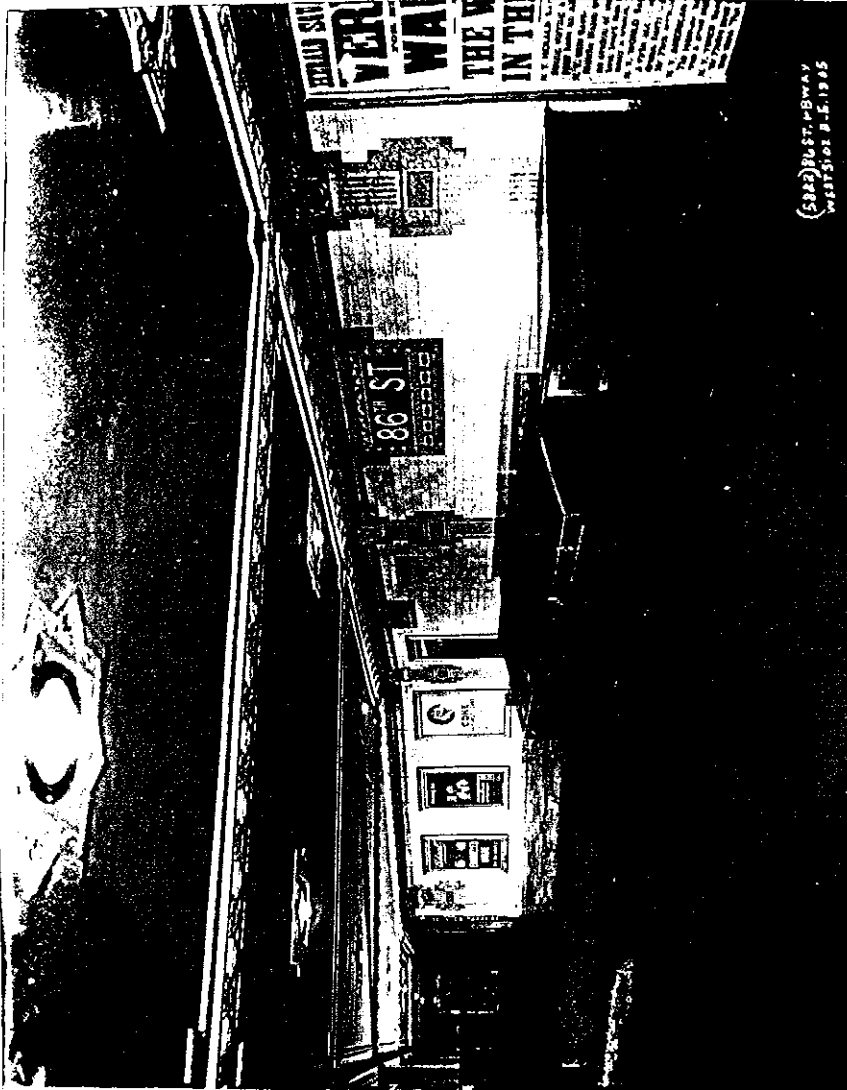
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STATION AT 129TH STREET AND BROADWAY.
FEBRAURY 15, 1905.



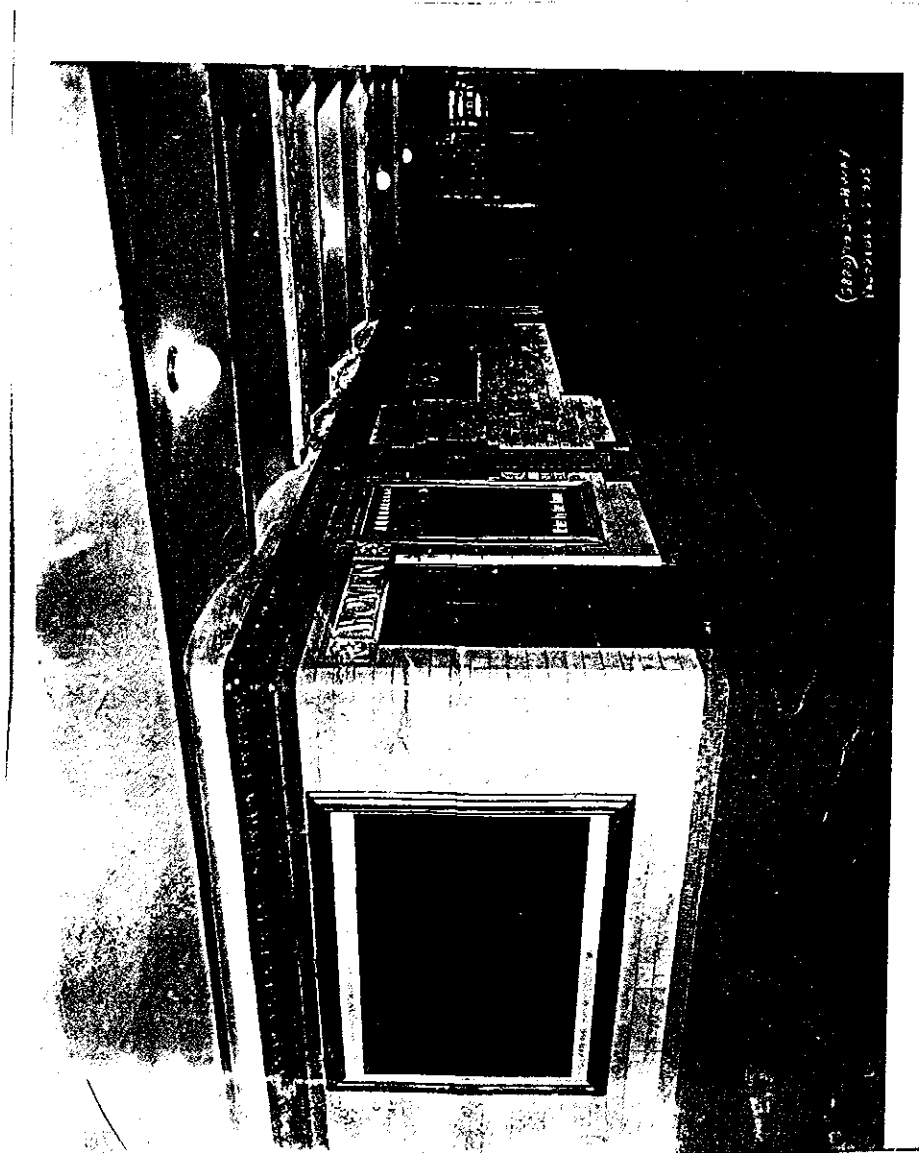
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Photocopied August 1978. (B)
INTERIOR OF STATION AT 110TH STREET AND LENOX AVENUE.
FEBRUARY 15, 1905.



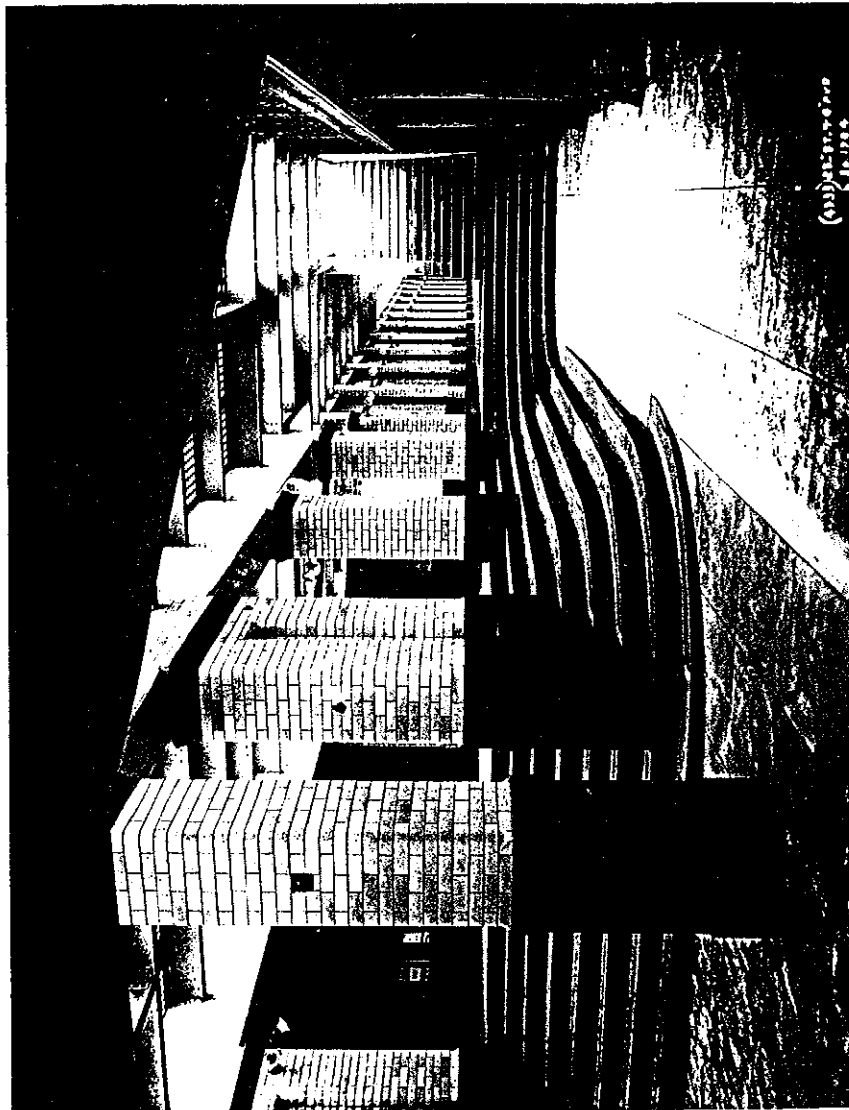
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WEST-SIDE INTERIOR OF STATION AT 86TH STREET AND
BROADWAY. FEBRUARY 5, 1905.



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RESTROOM ON EAST SIDE OF 79TH STREET STATION.
FEBRUARY 5, 1905.



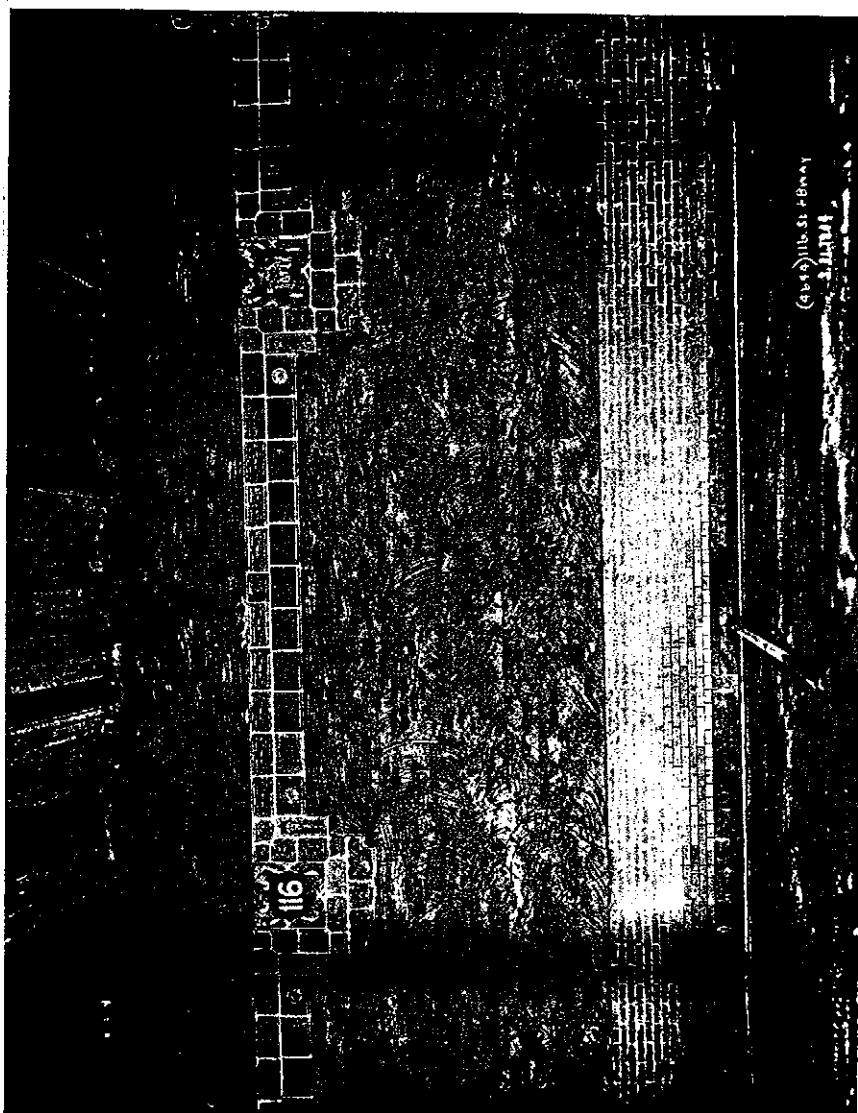
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Photocopied August 1978. (B)
STAIRWAYS, TILEWORK AND CEILING AT STATION AT 23RD
STREET AND 4TH AVENUE. JUNE 30, 1904.



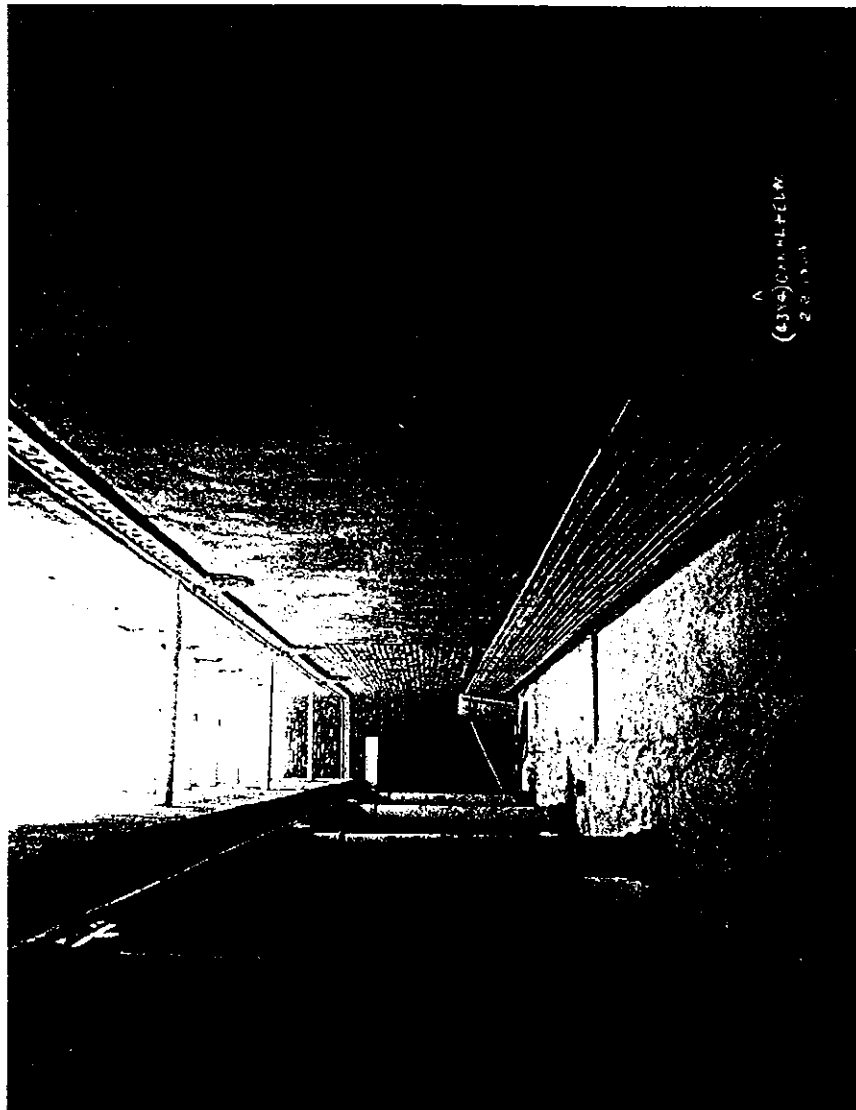
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Photocopied August 1978. (B)
UNFINISHED INTERIOR OF STATION AT BROADWAY AND 157TH
STREET.. OCTOBER 31, 1904.



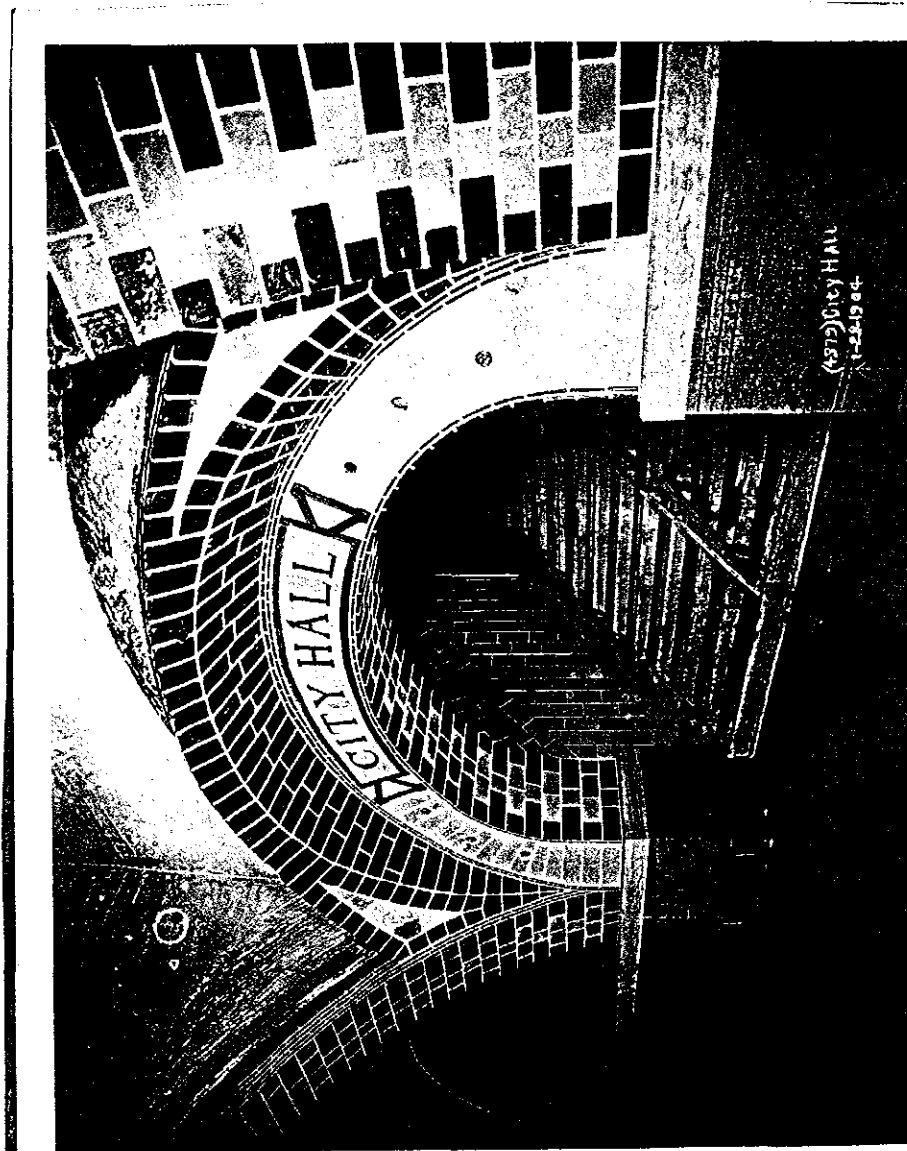
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Photocopied August 1978. (B)
UNFINISHED WALL AND PLATFORM AT 116TH STREET STATION.
MARCH 31, 1904.



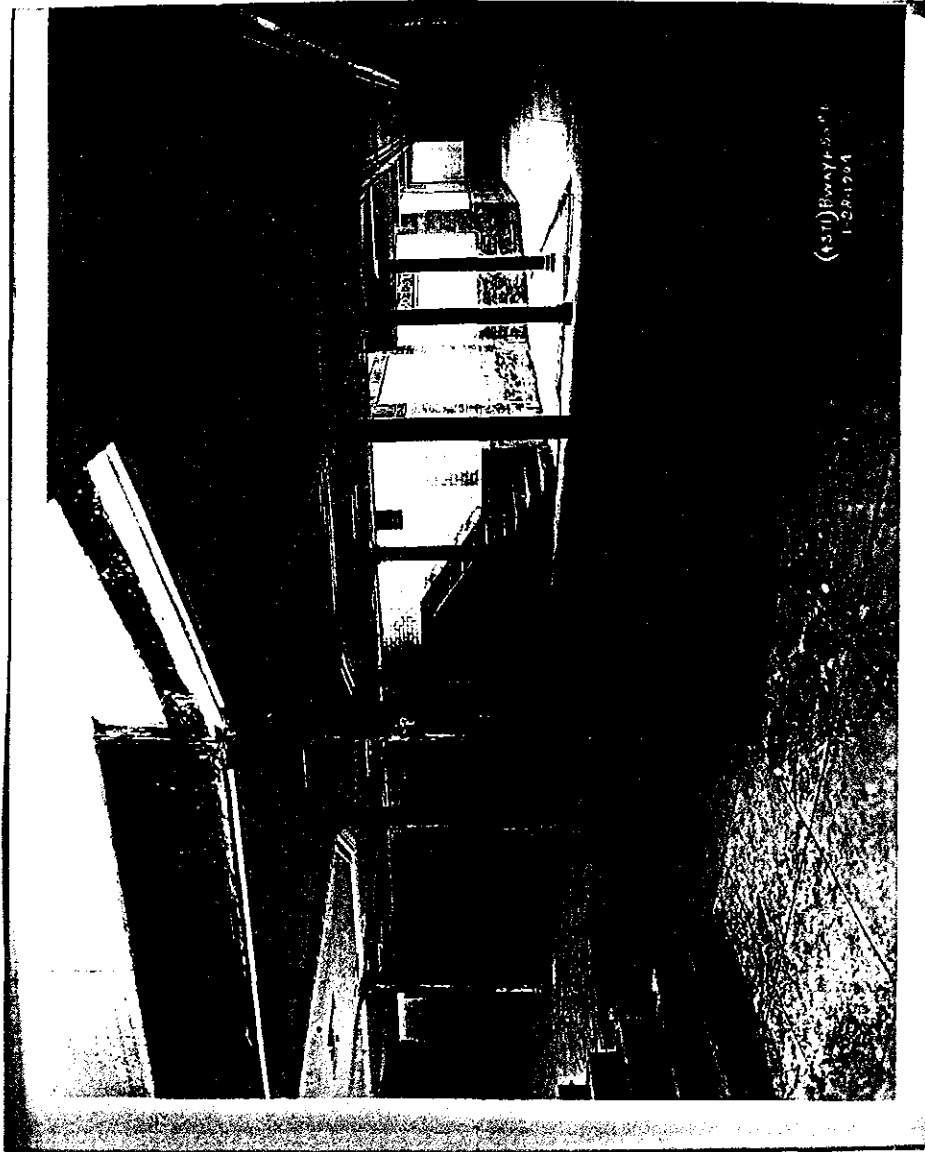
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WALL AND PLATFORM AT CANAL AND ELM. FEBRUARY 2, 1904



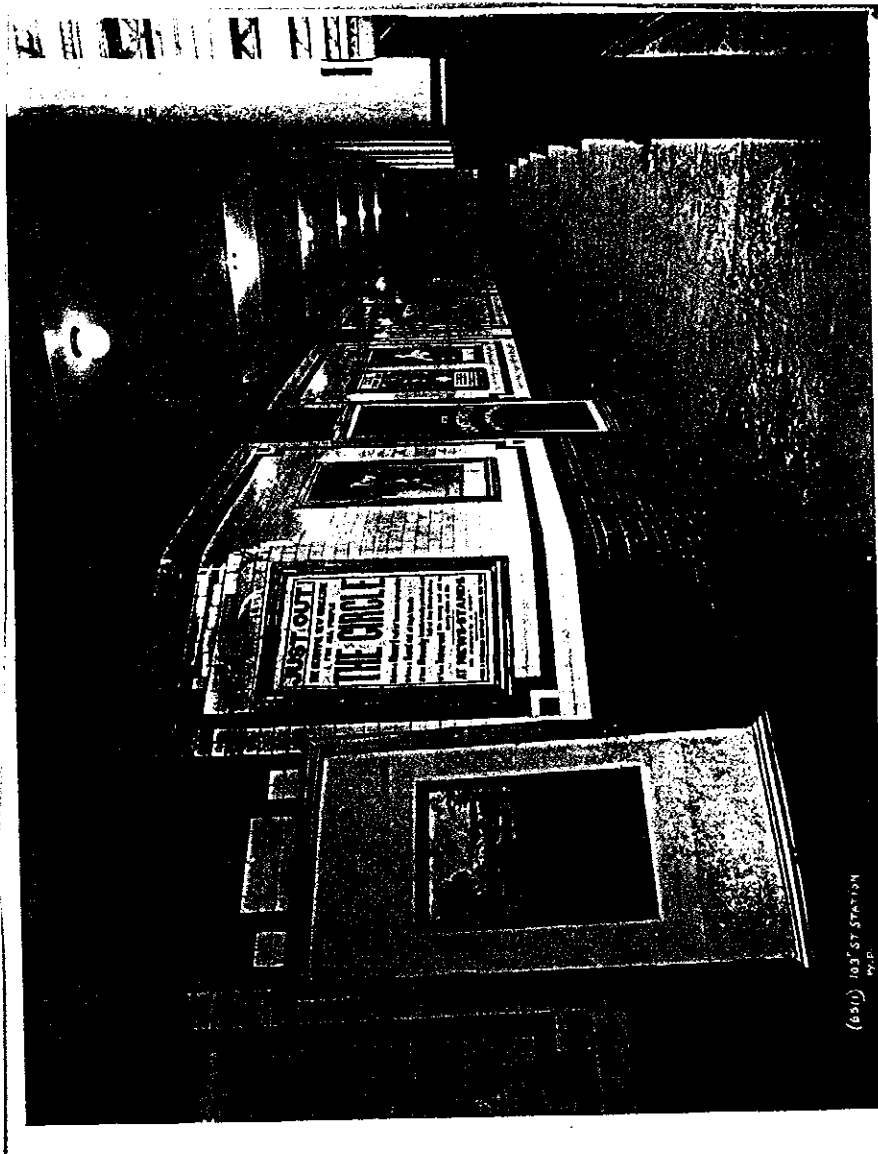
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Photocopied August 1978. (B)
INTERIOR OF CITY HALL STATION. JANUARY 28, 1904.



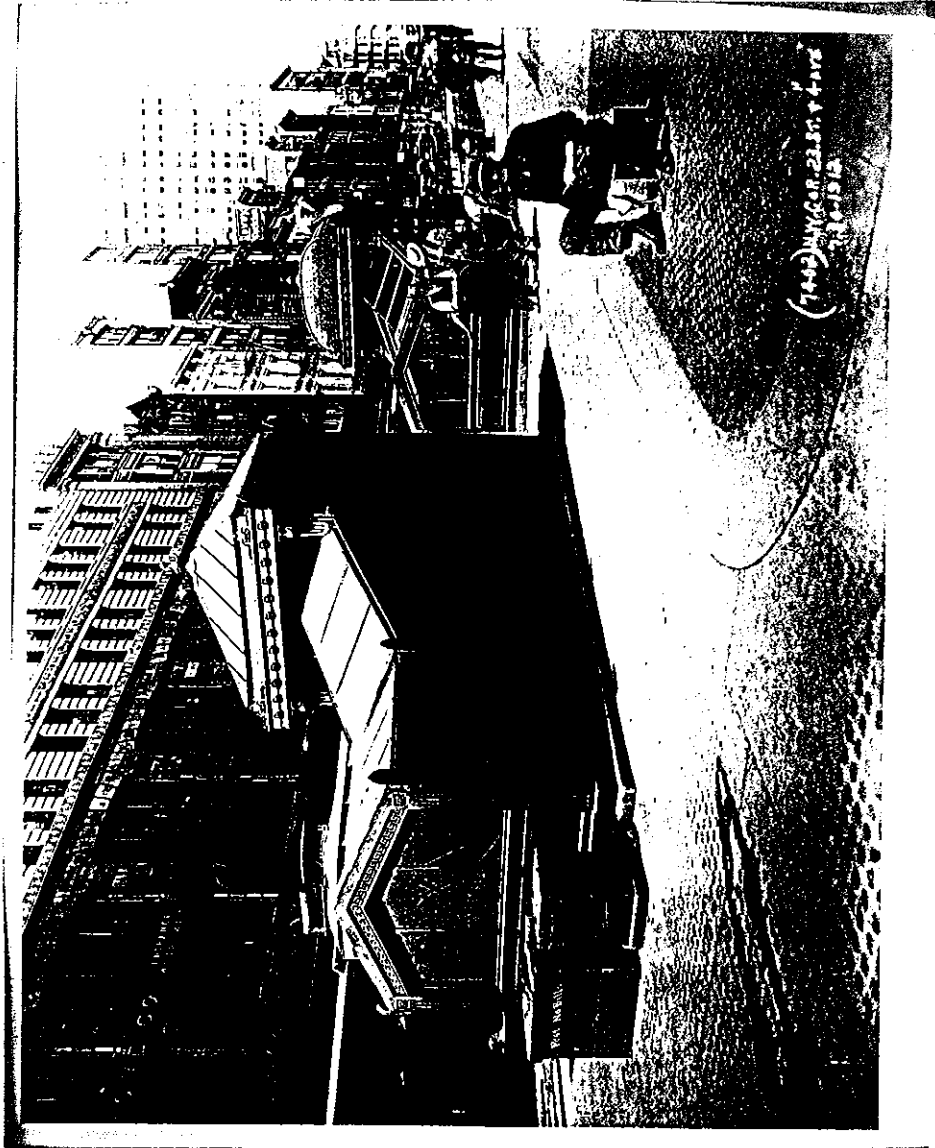
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Photocopied August 1978. (B)
INTERIOR OF 50TH STREET STATION. JANUARY 28, 1904.



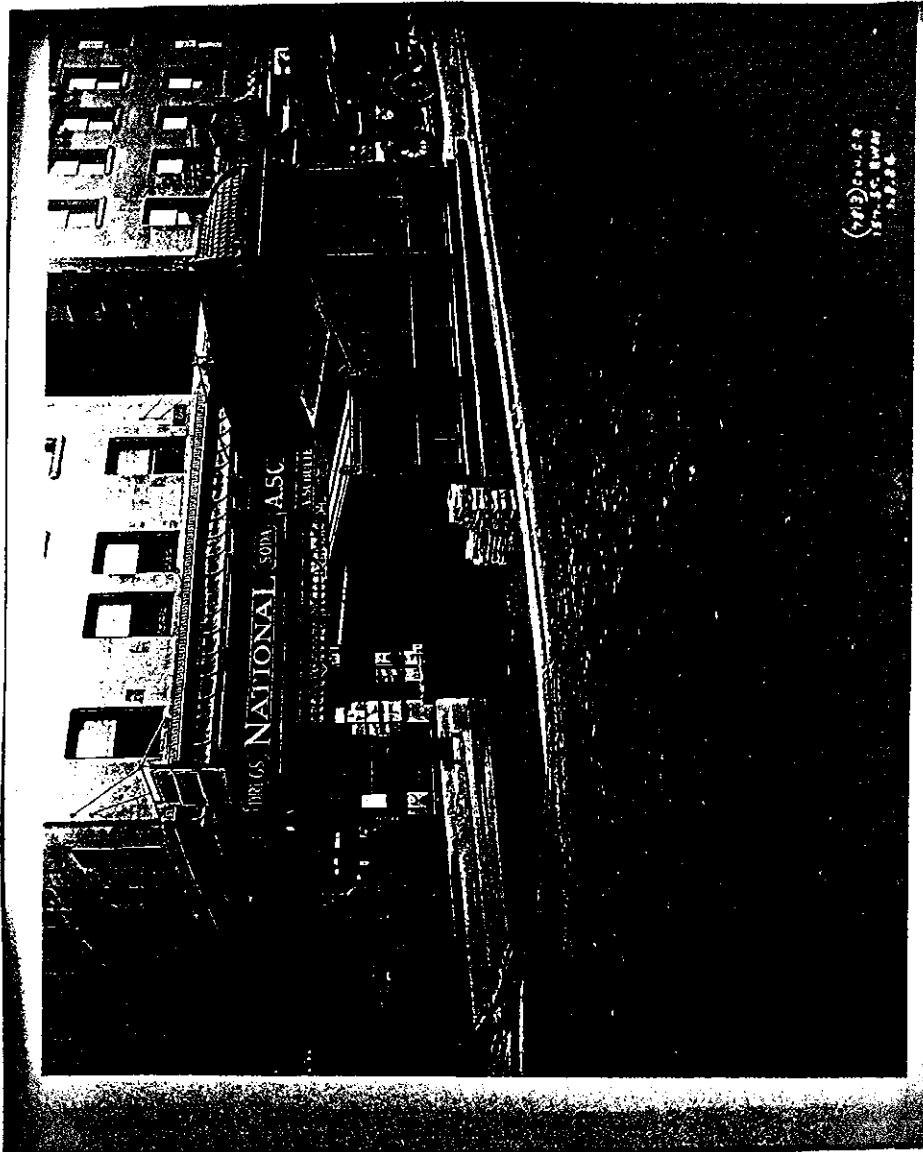
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VIEW SHOWING WALL (TILEWORK AND POSTERS) AND PLAT-
FORM AT 103RD STREET STATION.



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KIOSKS AT NORTHWEST CORNER OF 23RD STREET AND 4TH
AVENUE. JULY 30, 1912.



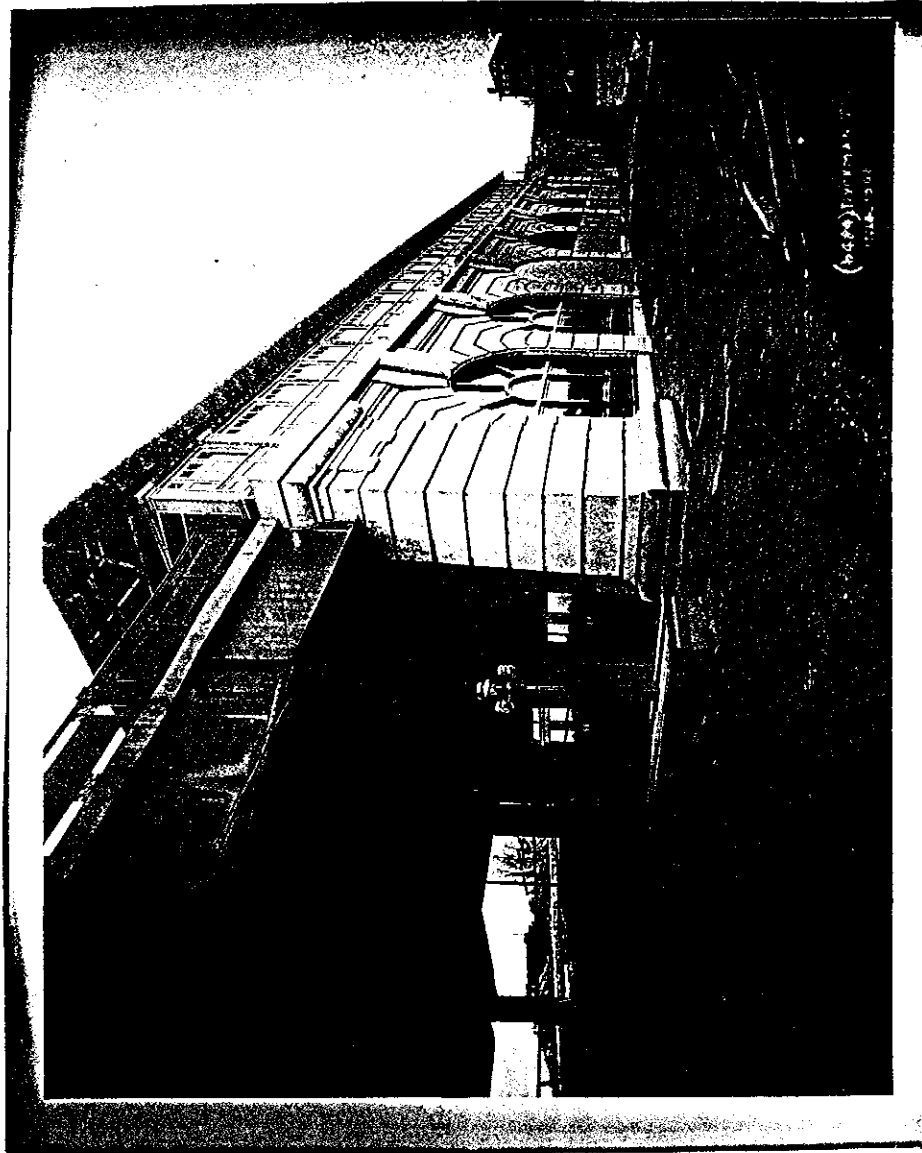
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Photocopied August 1978. (B)
KIOSK AT 157TH STREET AND BROADWAY. JANUARY 8, 1924.



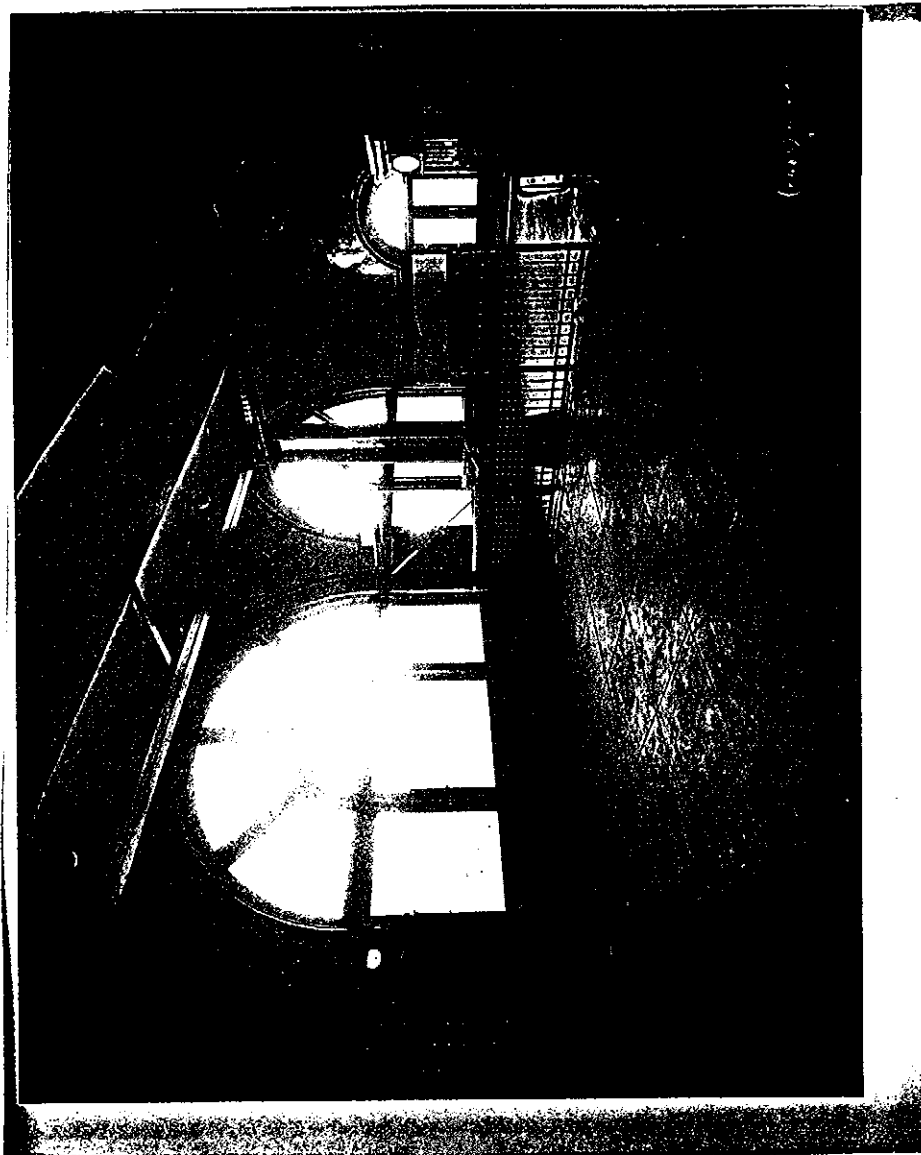
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SUBWAY ENTRANCE AT 14TH STREET STATION.
APRIL 23, 1912.



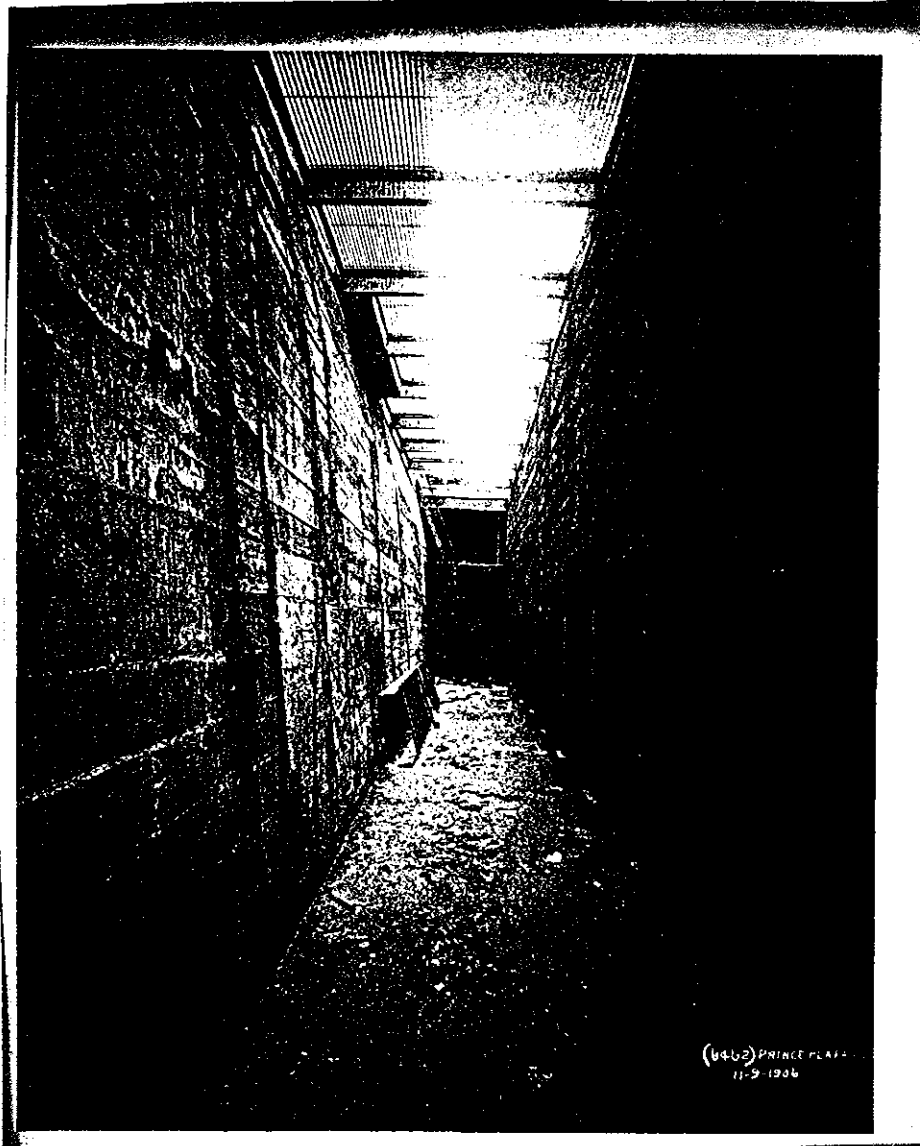
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Photocopied August 1978. (B)
ELEVATED TICKET OFFICE AT DYCKMAN STREET.
NOVEMBER 14, 1906.



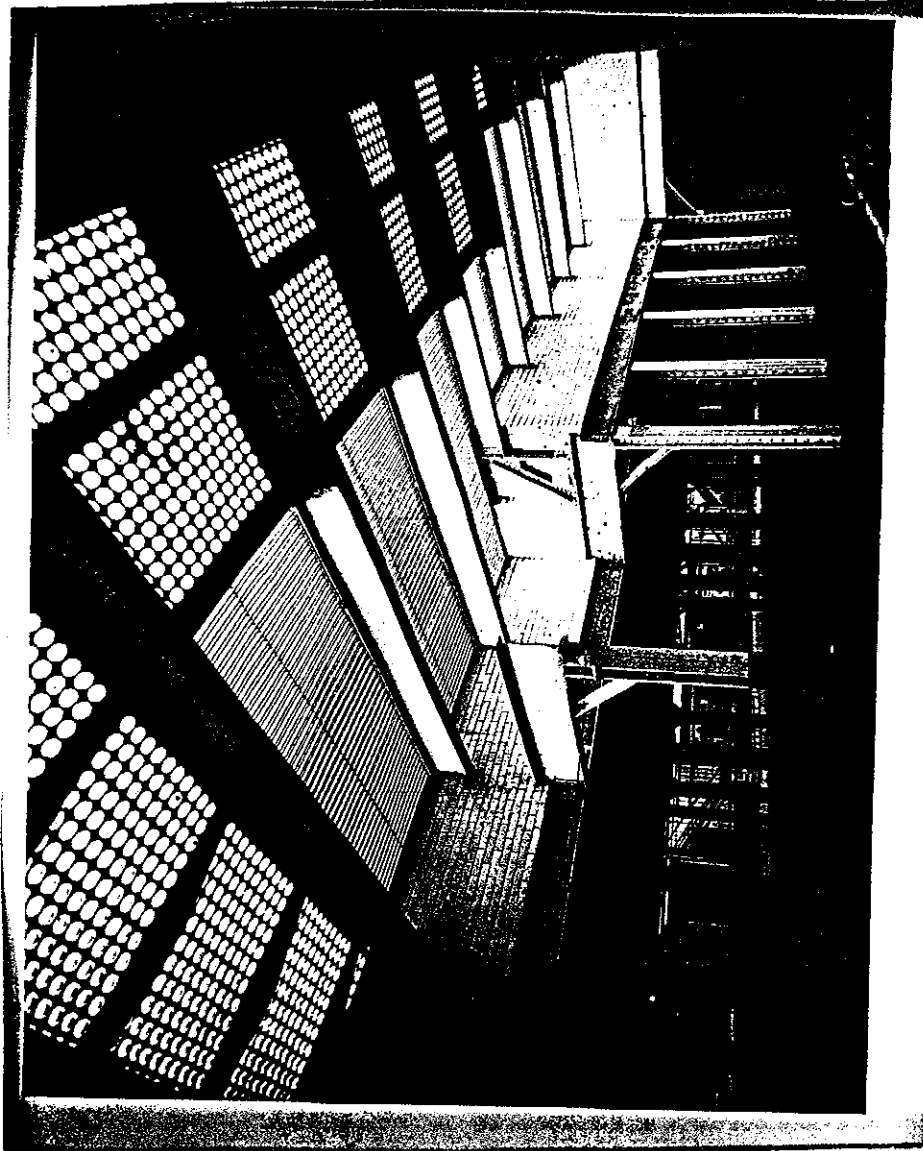
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Photocopied August 1978. (B)
INTERIOR OF DYCKMAN STREET STATION. NOVEMBER 14, 1906.



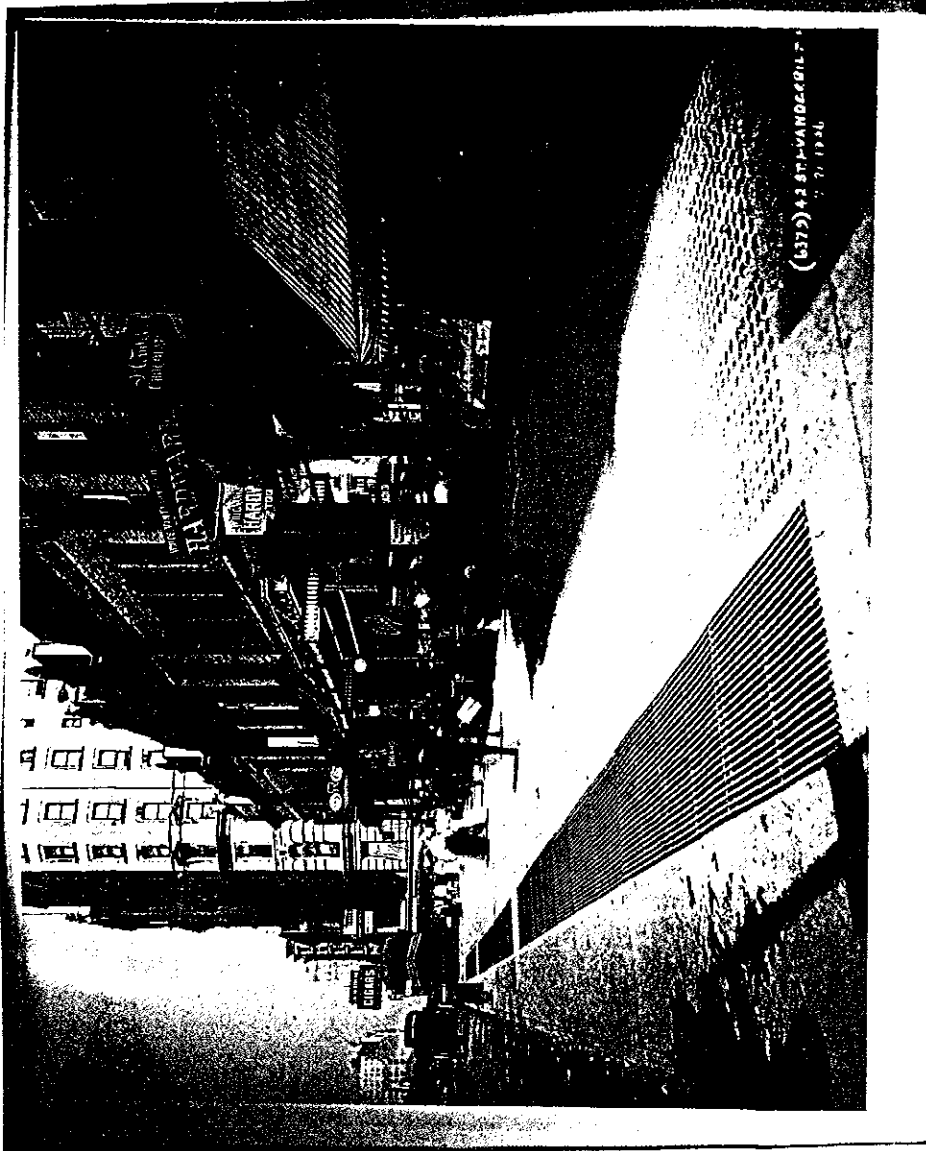
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Photocopied August 1978. (8)
OPEN GRATINGS AT PRINCE AND LAFAYETTE STREETS.
NOVEMBER 9, 1906.



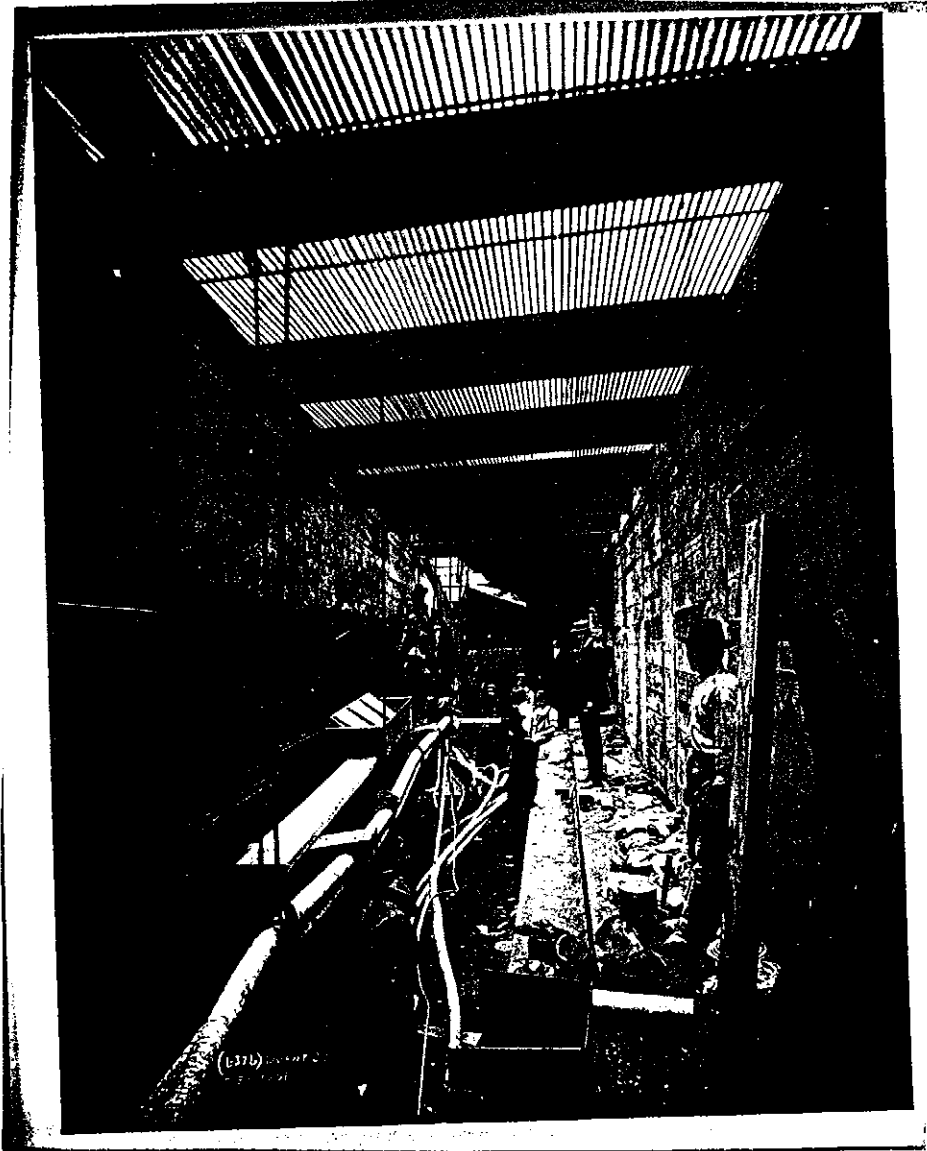
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Photocopied August 1978. (B)
NATURAL LIGHTING (VAULT LIGHTS) AT COLUMBUS CIRCLE.
JULY 31, 1906.



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SIDEWALK WITH GRATING AND VAULT LIGHTS AT 42ND
STREET AND VANDERBILT. JULY 31, 1906.



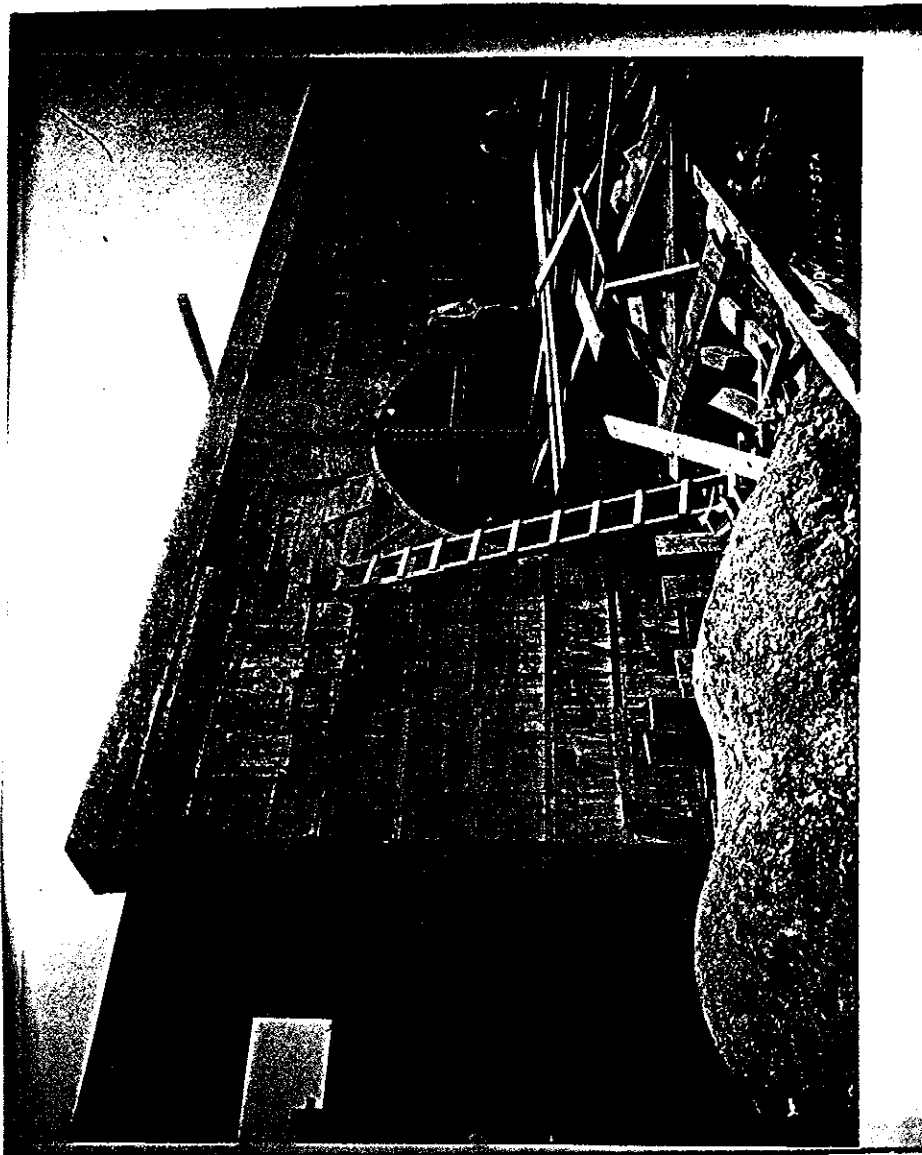
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Photocopied August 1978. (B)
WORKMEN BENEATH SIDEWALK GRATING. JULY 30, 1906.



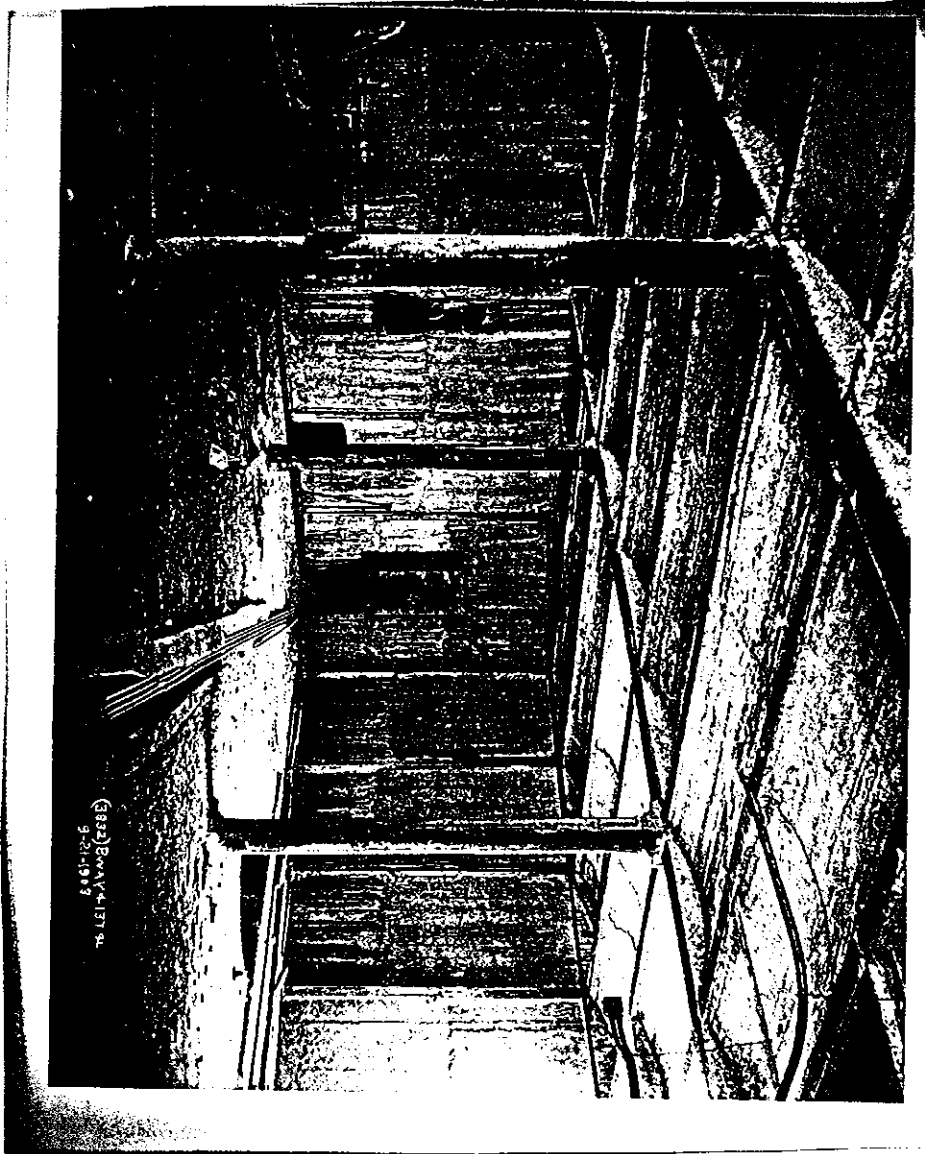
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Photocopied August 1978. (B)
STAIRWAY AND ENTRANCE TO 207TH STREET STATION. NOTE
DECORATIVE IRONWORK. C.1906.



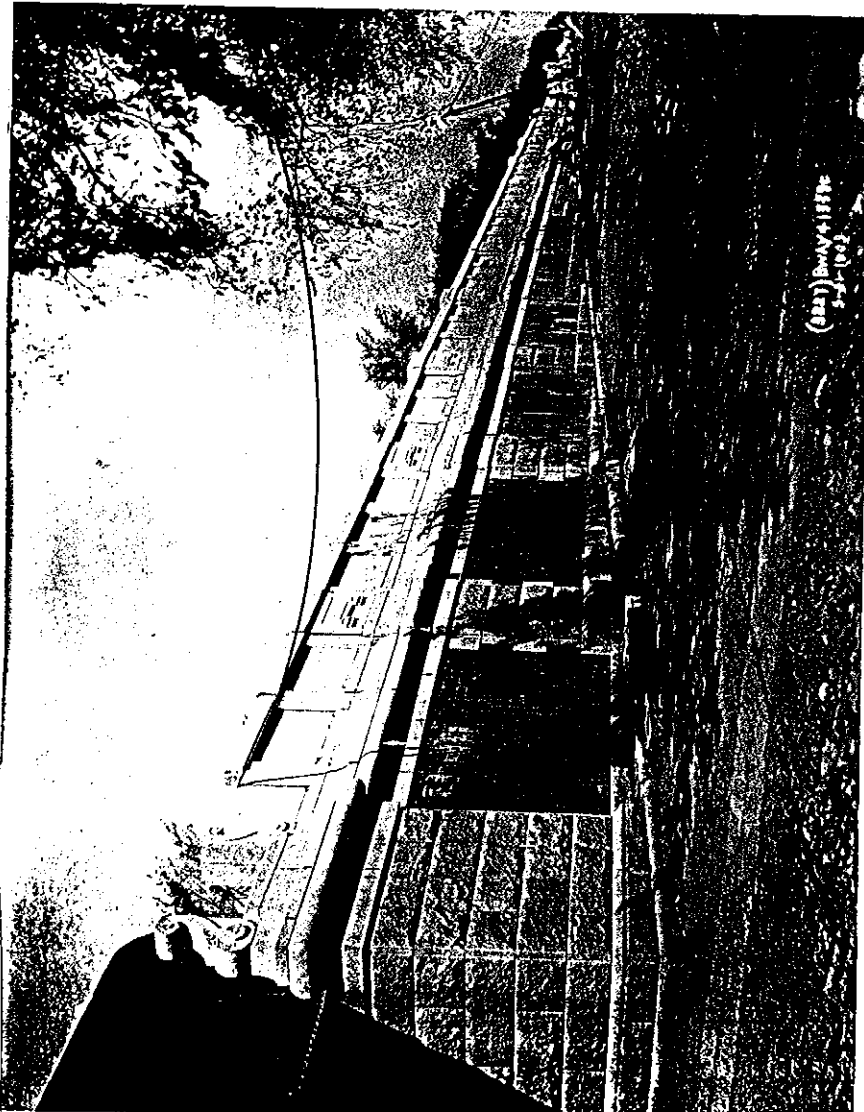
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Photocopied August 1978. (B)
CONSTRUCTION OF DYCKMAN STREET STATION. JUNE 9, 1905.



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Photocopied August 1978. (8)
CONCRETE WORK, CONDUITS AND VAULTING AT UNFINISHED
STATION AT 137TH STREET AND BROADWAY.



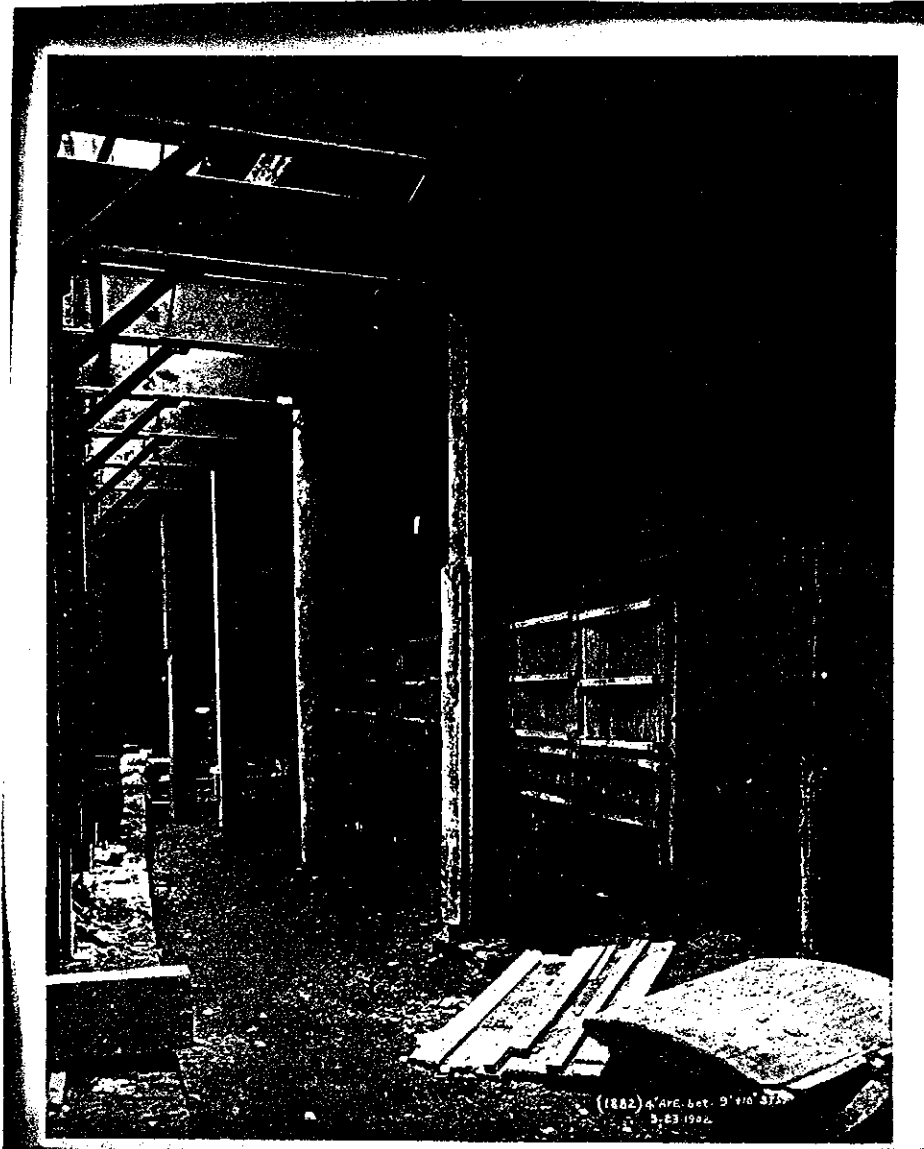
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
MASONRY VIADUCT AT BROADWAY AND 133RD STREET (NORTH
SIDE APPROACH TO MANHATTAN VALLEY VIADUCT).
SEPTEMBER 21, 1903.



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Photocopied August 1978. (B)
TRACK, STEEL-WORK AND PLATFORM AT UNFINISHED STATION
AT 28TH STREET AND 4TH AVENUE. AUGUST 18, 1903.



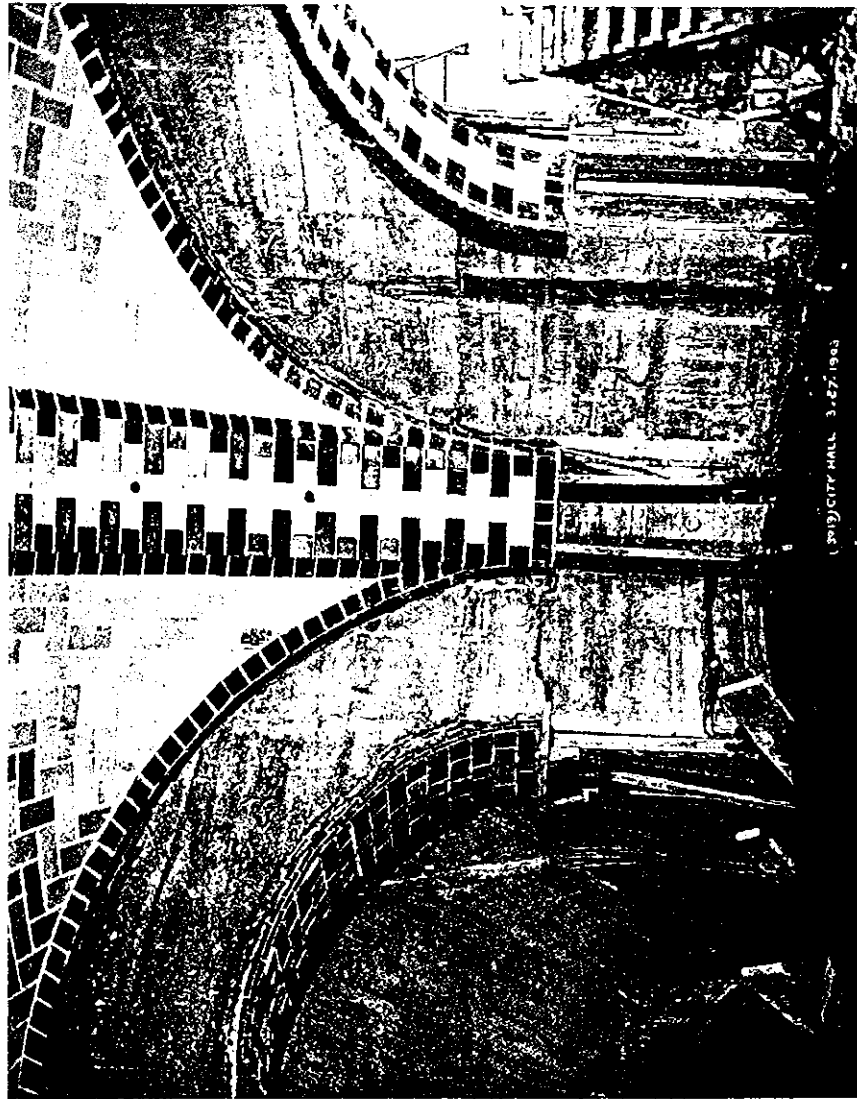
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Photocopied August 1978. (8)
4TH AVENUE BETWEEN 9TH AND 10TH STREETS. VIEW OF
STRUCTURAL MEMBERS. MAY 23, 1902.



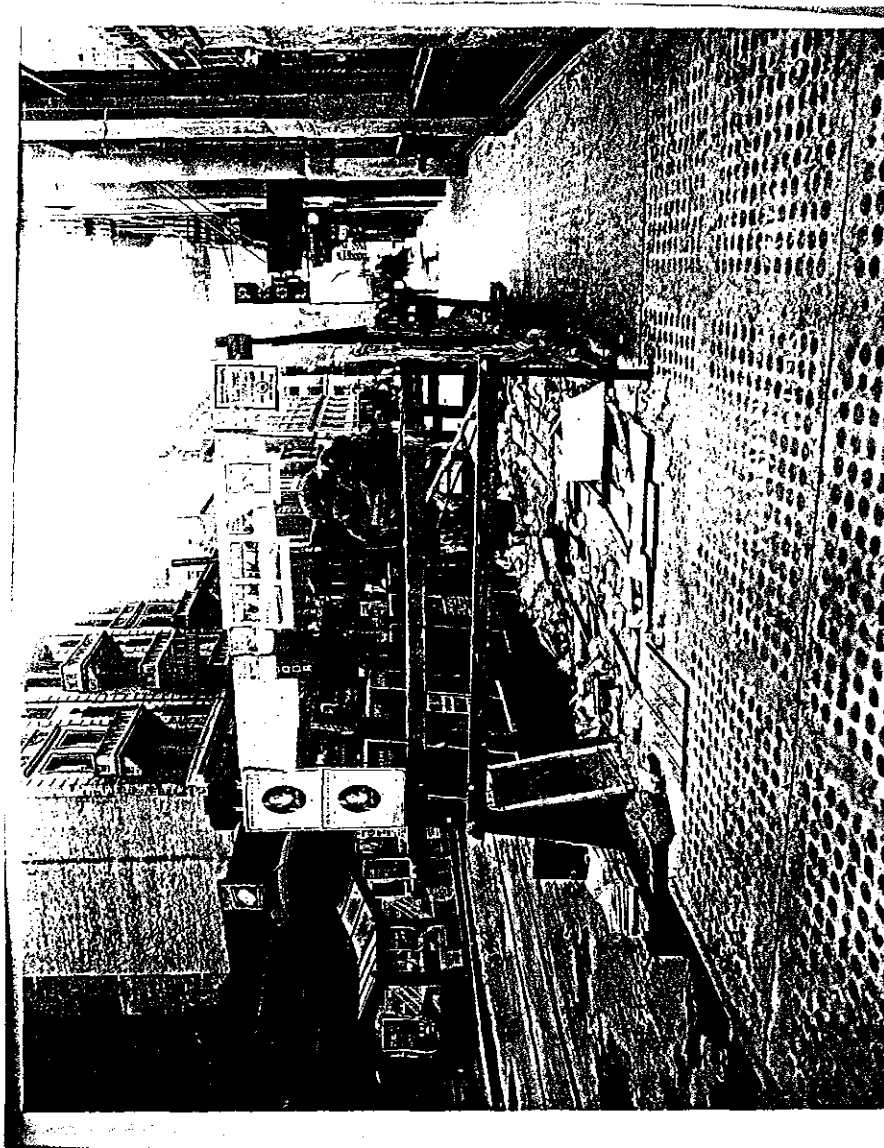
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Photocopied August 1978. (B)
BROADWAY AND 50TH STREET. CONSTRUCTION.
APRIL 26, 1904.



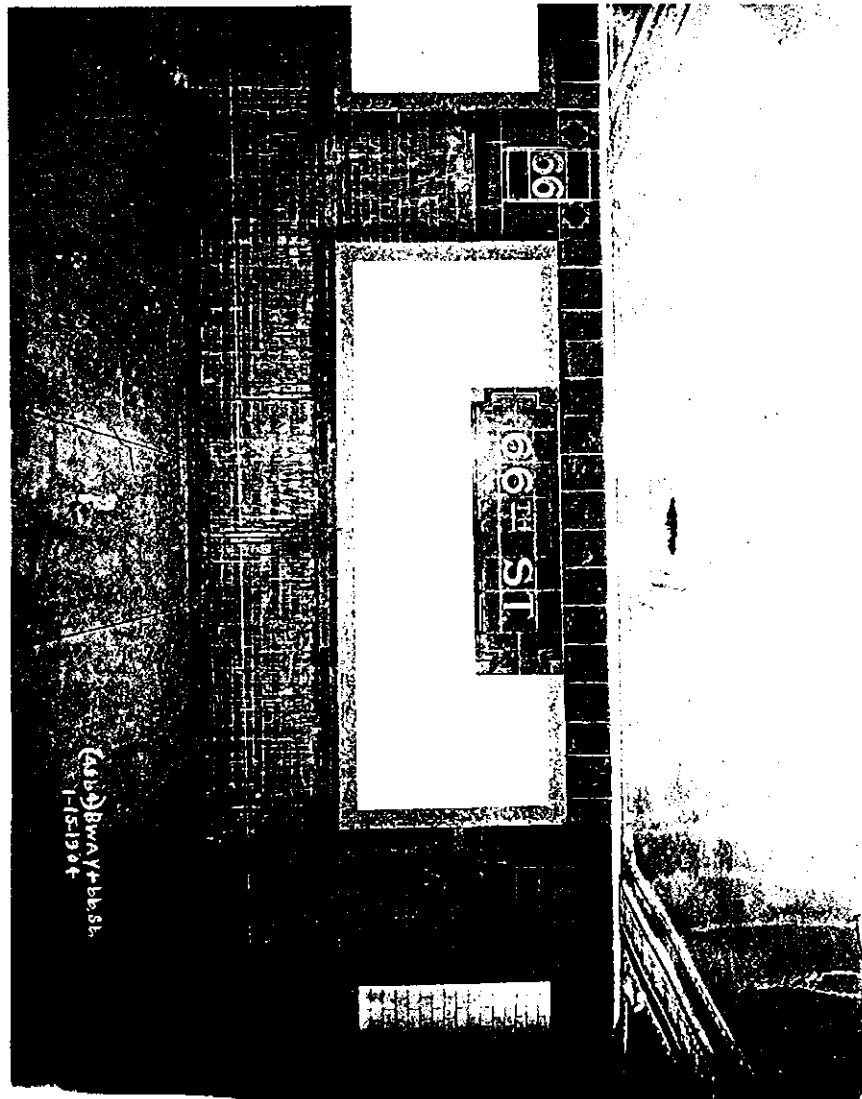
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
TILE-WORK AT UNFINISHED CITY HALL STATION.
MARCH 27, 1903.



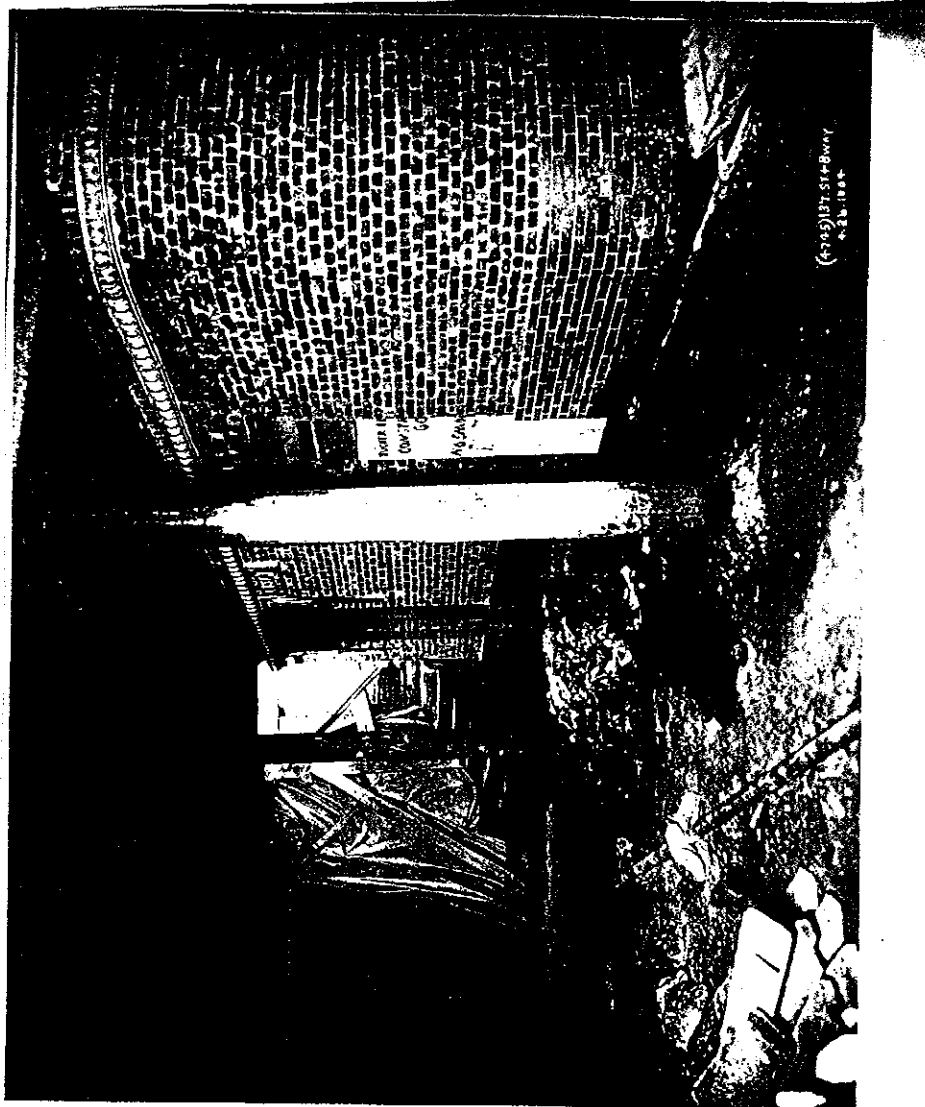
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
AFTER DEMOLITION OF KIOSK AT 28TH STREET AND 4TH
AVENUE.



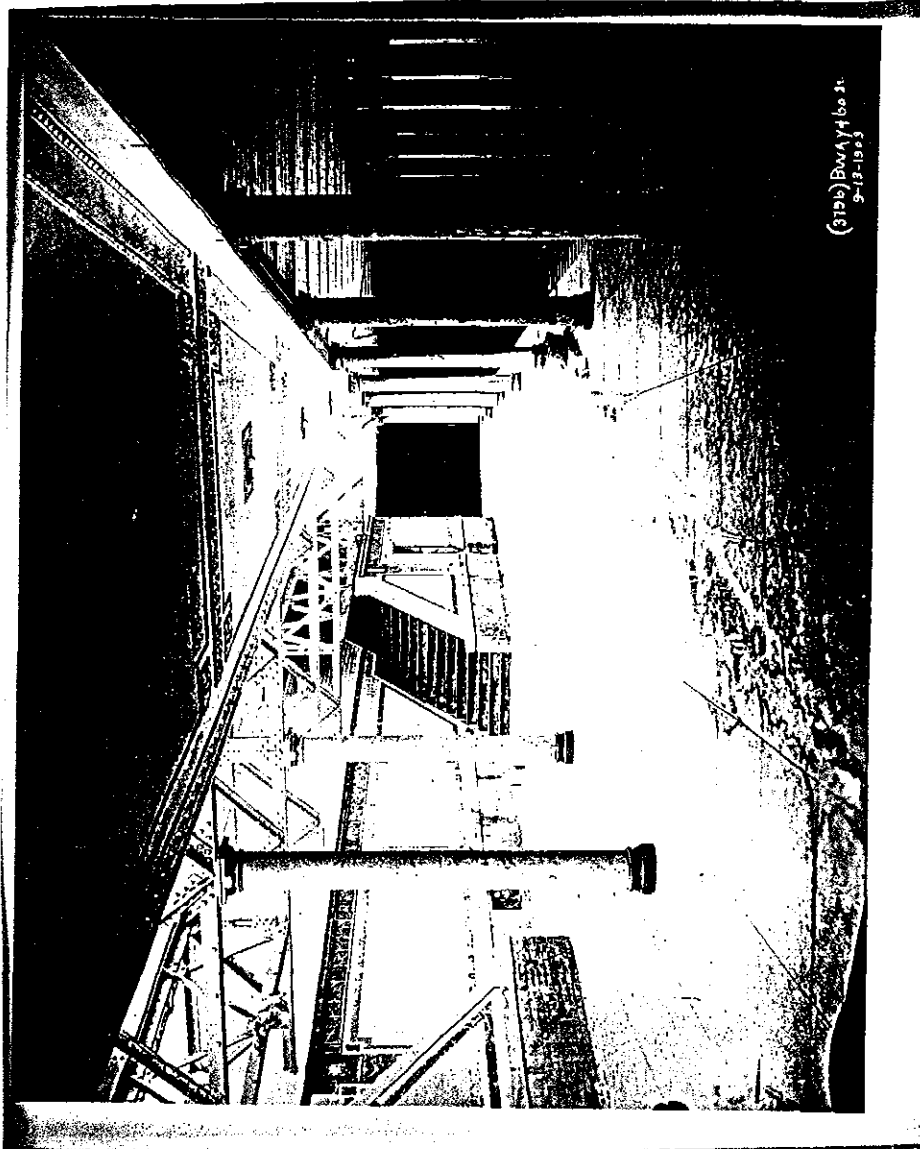
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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
SHOWING STATION SIGN (WALL PLAQUE) AT 66TH STREET.



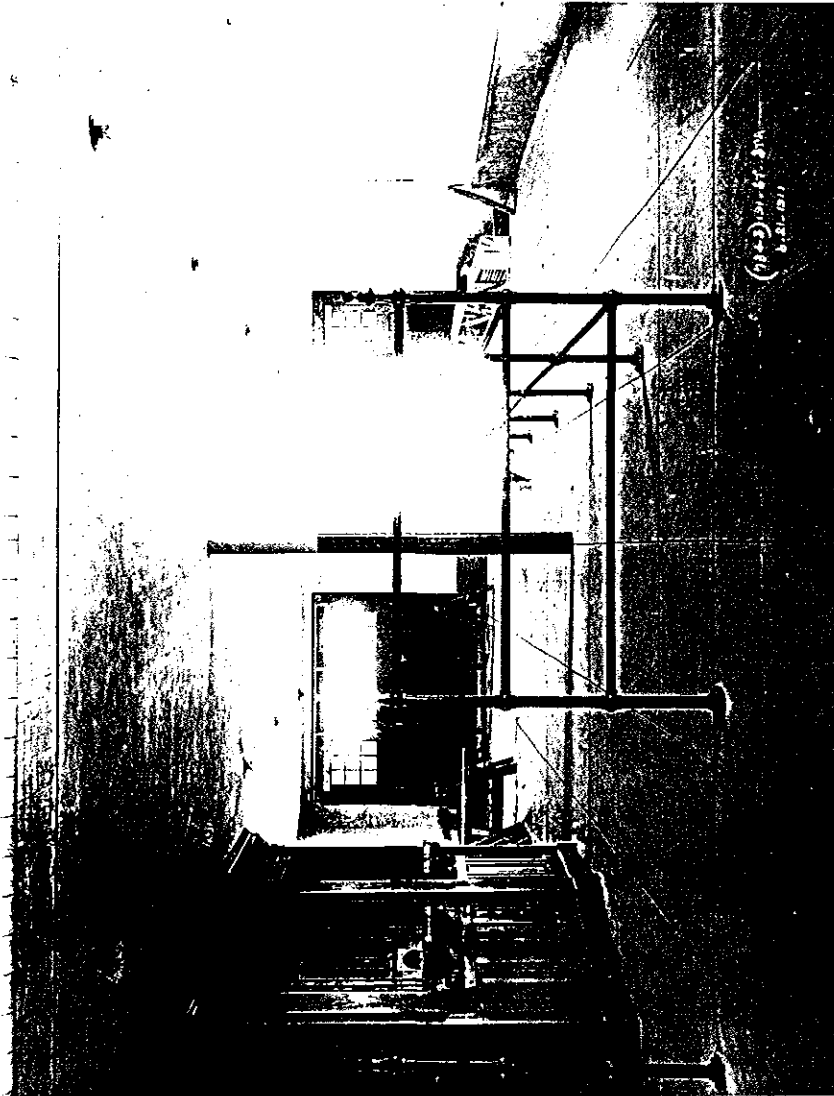
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Photocopied August 1978. (B)
CONSTRUCTION AT 134TH STREET AND BROADWAY.
APRIL 26, 1904.



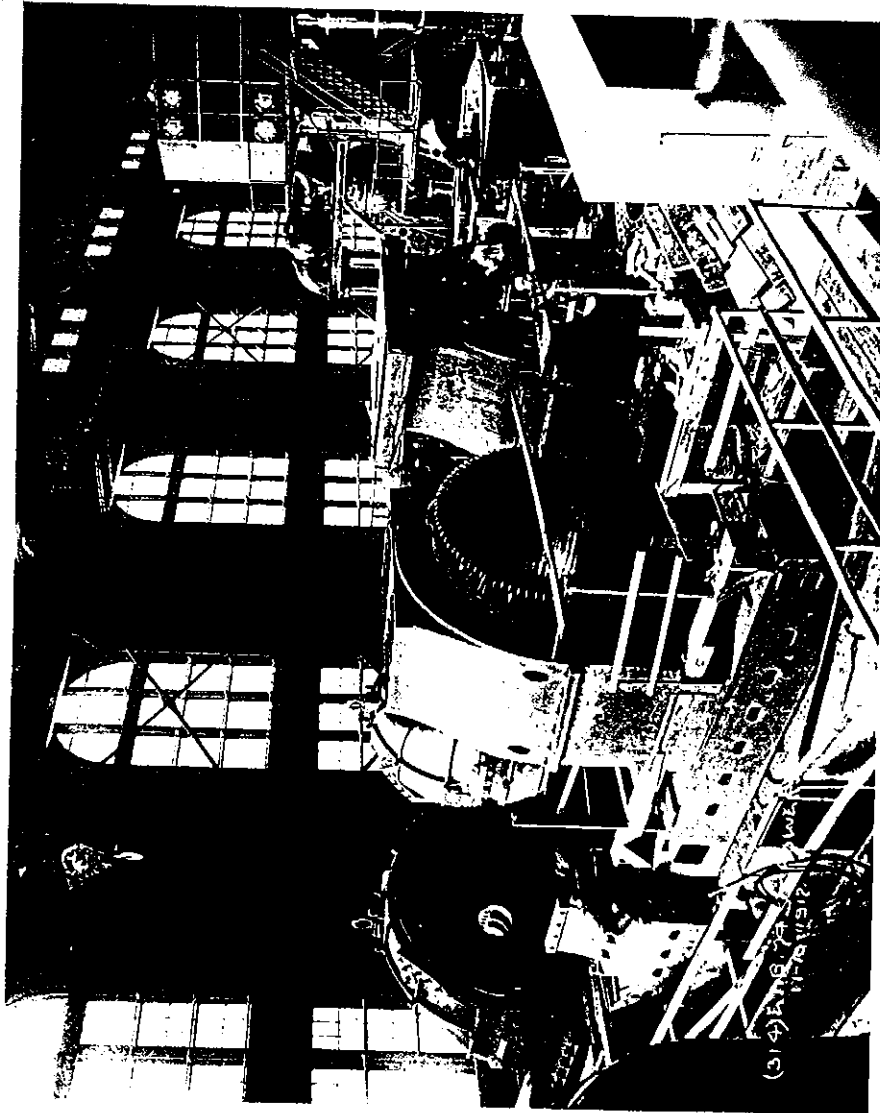
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Photocopied August 1978. (B)
TRACK AND PLATFORM AT BROADWAY AND 60TH STREET STATION.
SEPTEMBER 13, 1903.



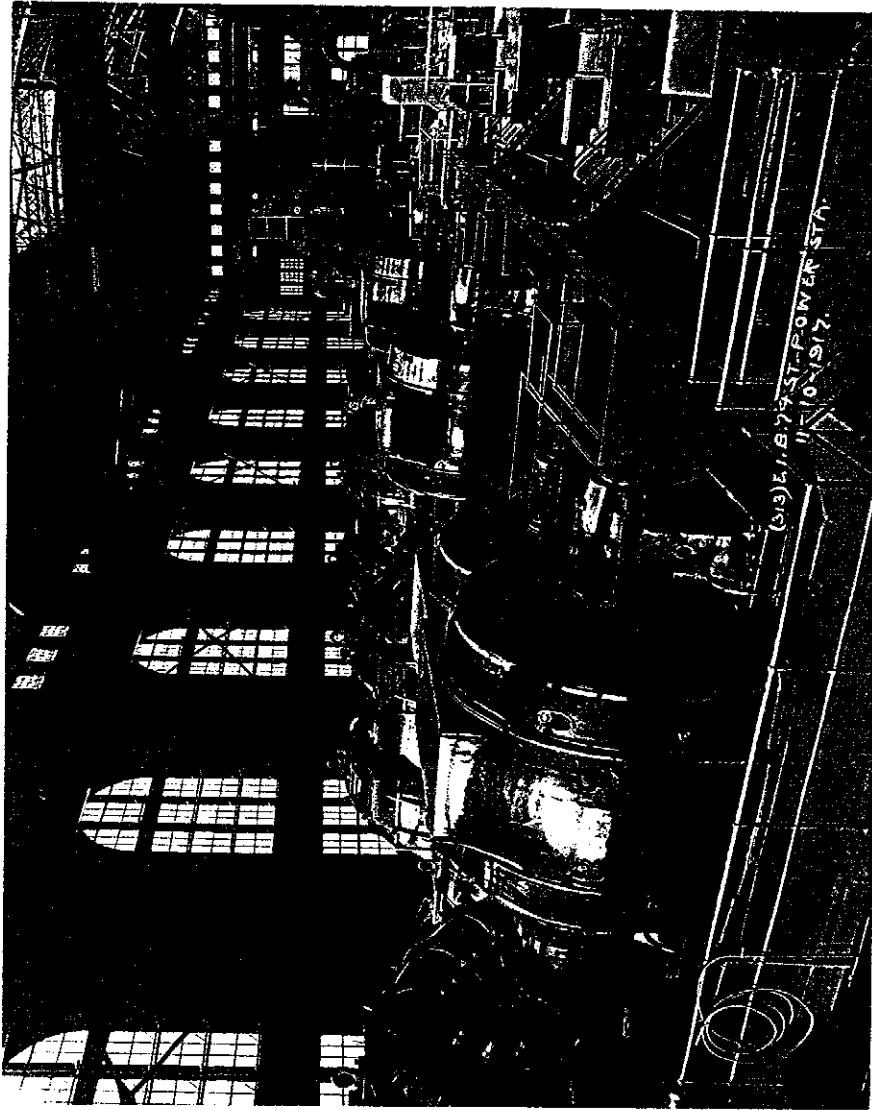
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Photocopied August 1978. (B)
TICKET BOOTH AT 191ST STREET STATION. JUNE 21, 1911.



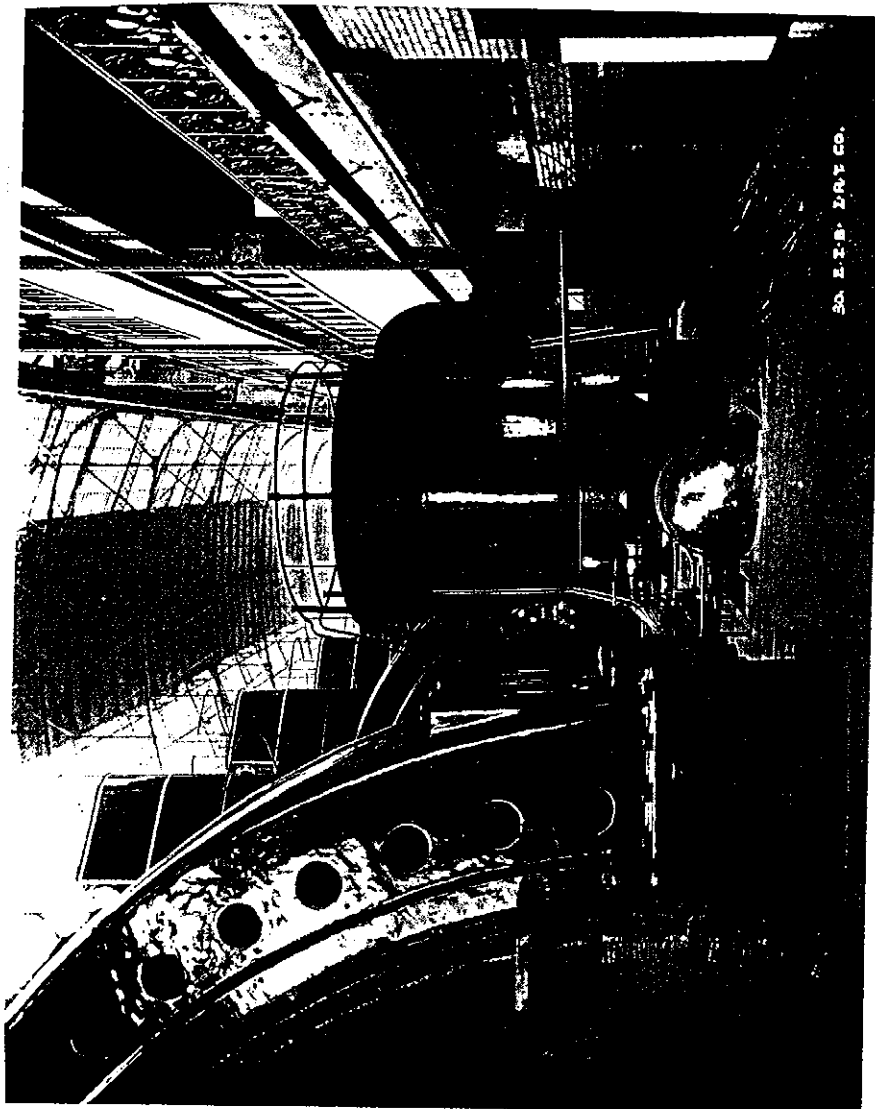
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
INSTALLATION IN PROGRESS OF TURBINE GENERATORS AT
EAST SIDE OF 74TH STREET POWER STATION.
NOVEMBER 10, 1912.



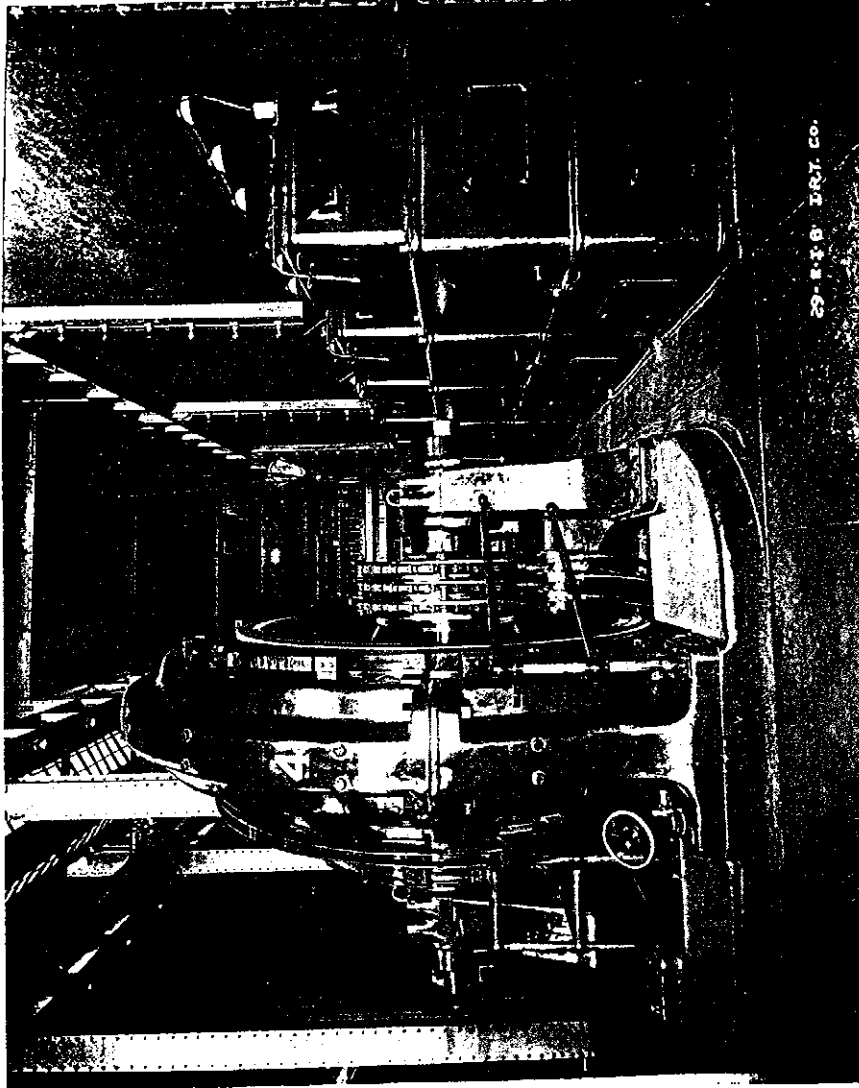
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
TURBINE GENERATORS AT EAST SIDE OF 74TH STREET POWER
STATION. NOVEMBER 10, 1917.



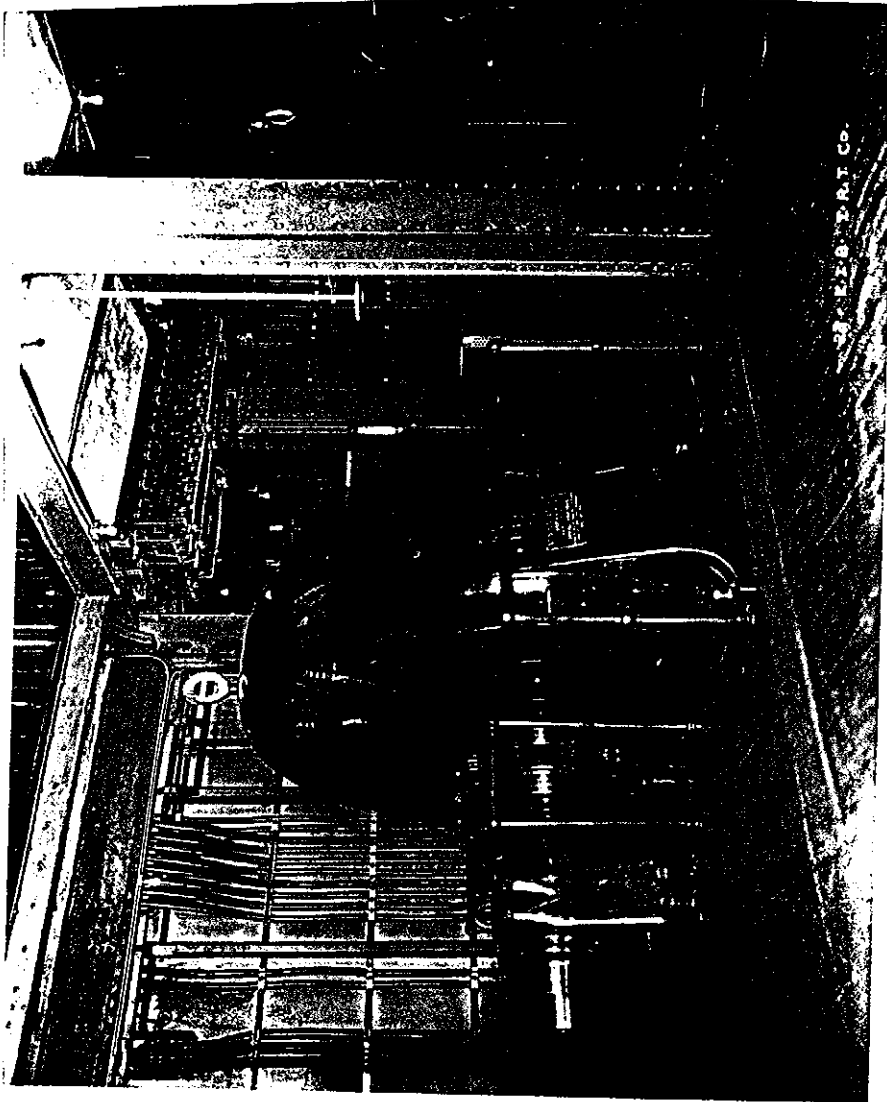
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
INTERIOR OF GENERATOR ROOM AT MAIN IRT POWERHOUSE.



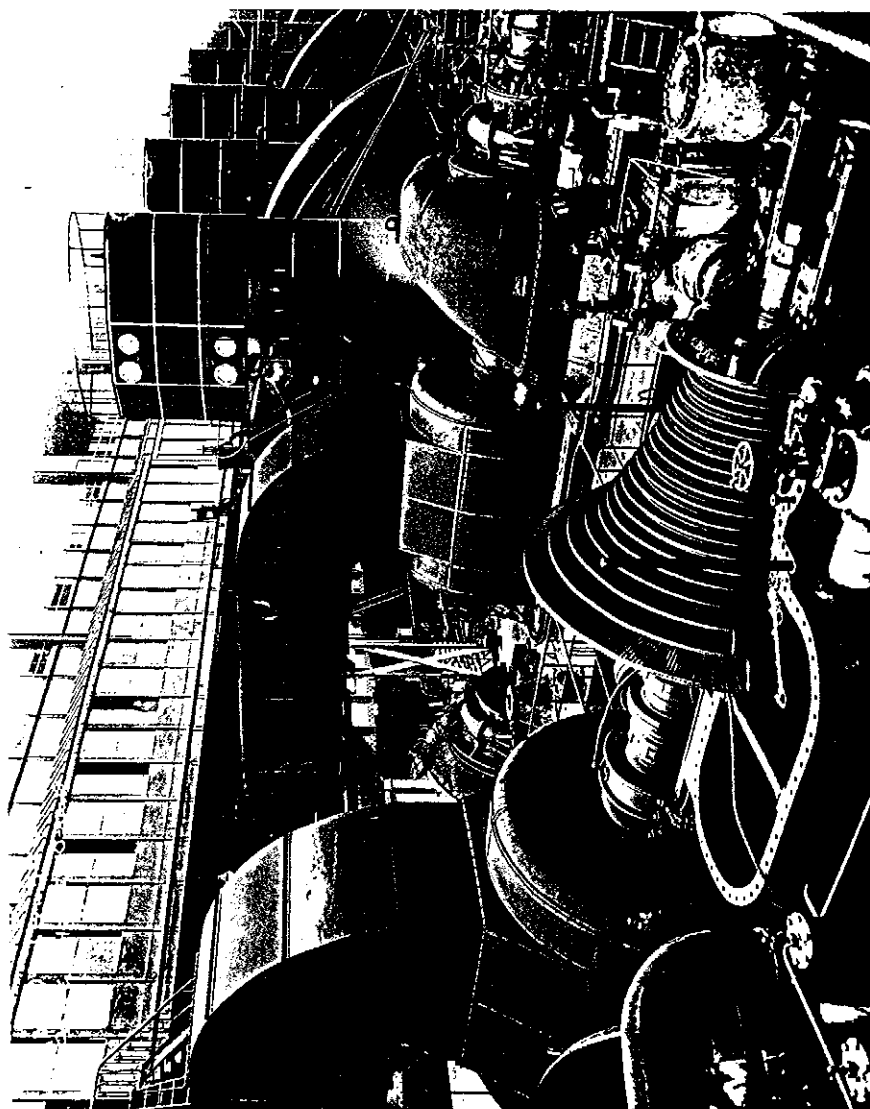
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Photocopied August 1978. (B)
ROTARY CONVERTER.



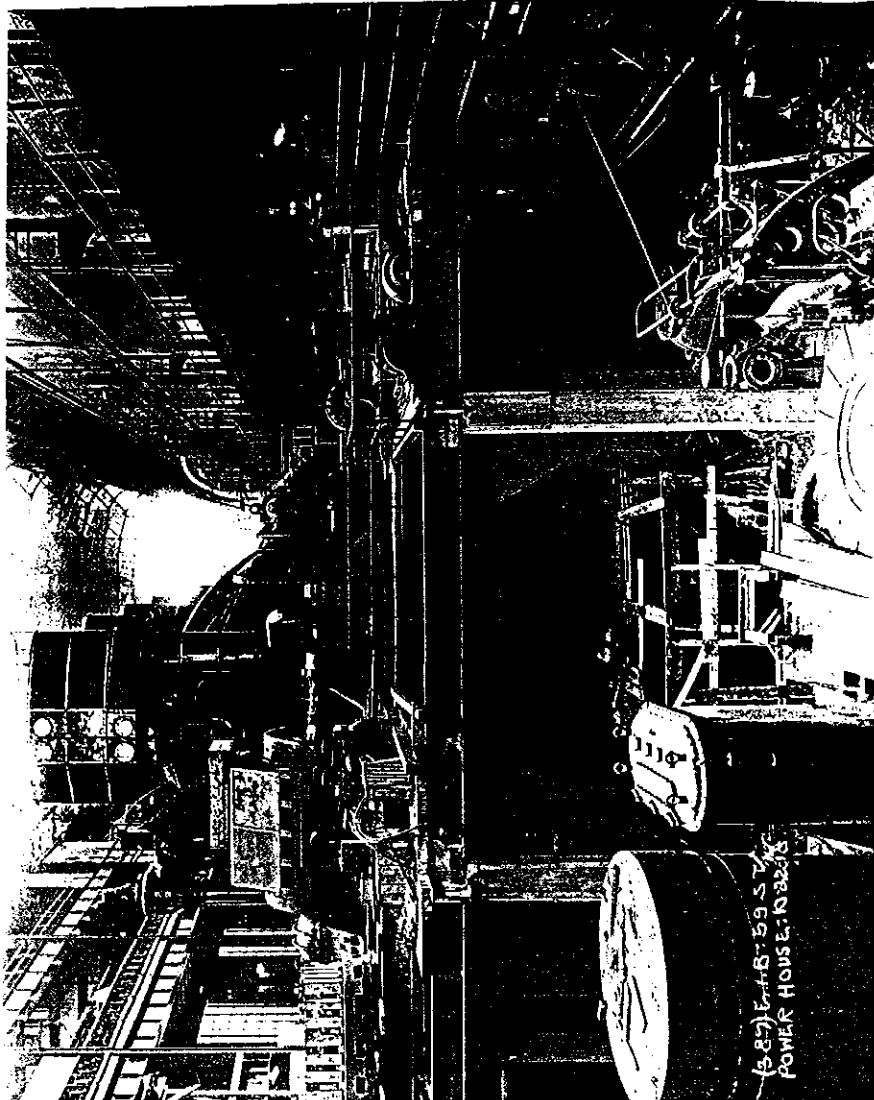
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
UNIDENTIFIED IRT SUBSTATION. NOTE HARDWOOD FRAME
SUPPORTING THE ROTARY CONVERTER, INDEPENDENT OF
THE SUBSTATION FLOOR.



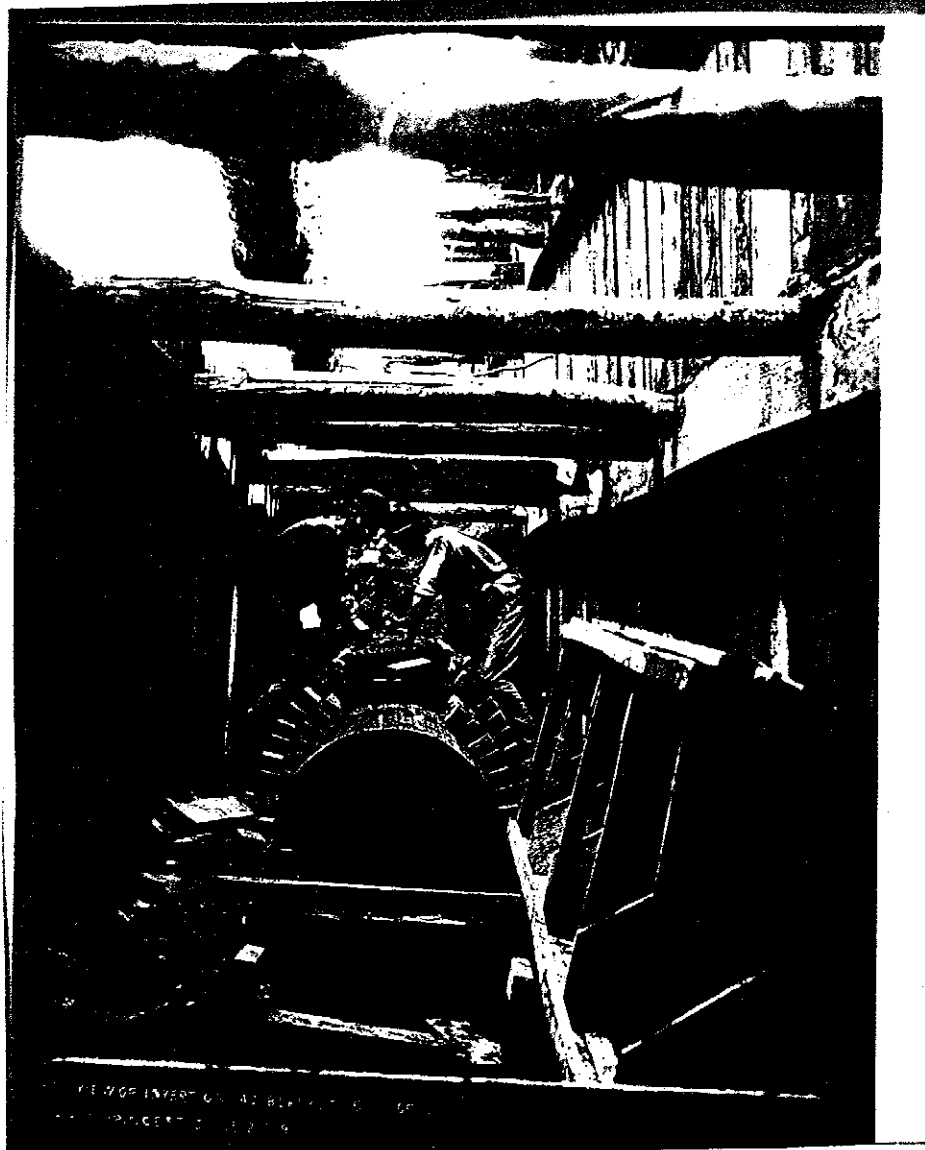
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (8)
IRT MAIN POWERHOUSE. INSTALLATION OF TURBO-GENERATOR
UNITS. 1918.



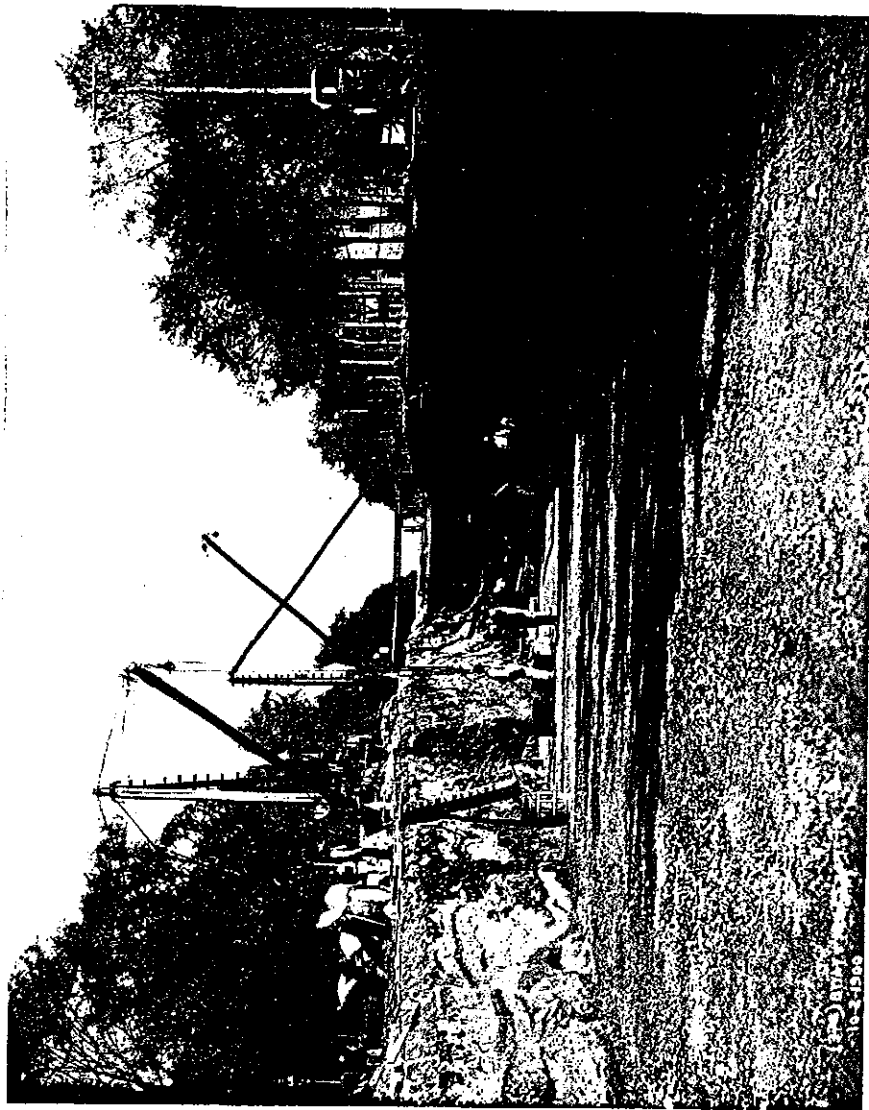
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
IRT MAIN POWERHOUSE. INSTALLATION OF TURBO-GENERATOR
UNITS. 1918.



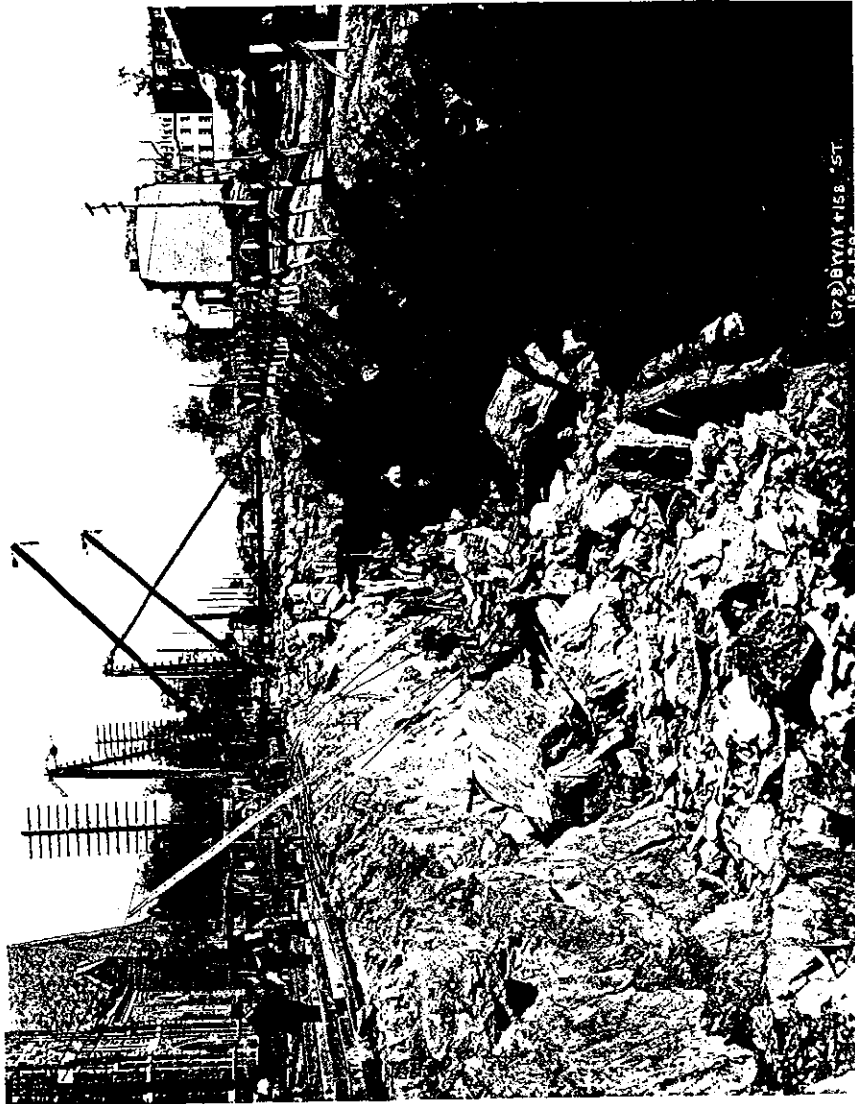
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (8)
VIEW OF INVERT ON MULBERRY STREET. RECONSTRUCTION
OF SEWER. JUNE 21, 1900.



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Photocopied August 1978. (8)
OPEN EXCAVATION AT BROADWAY AND 134TH STREET JUST
PRIOR TO LAYING OF CONCRETE FLOOR. OCTOBER 2, 1900.



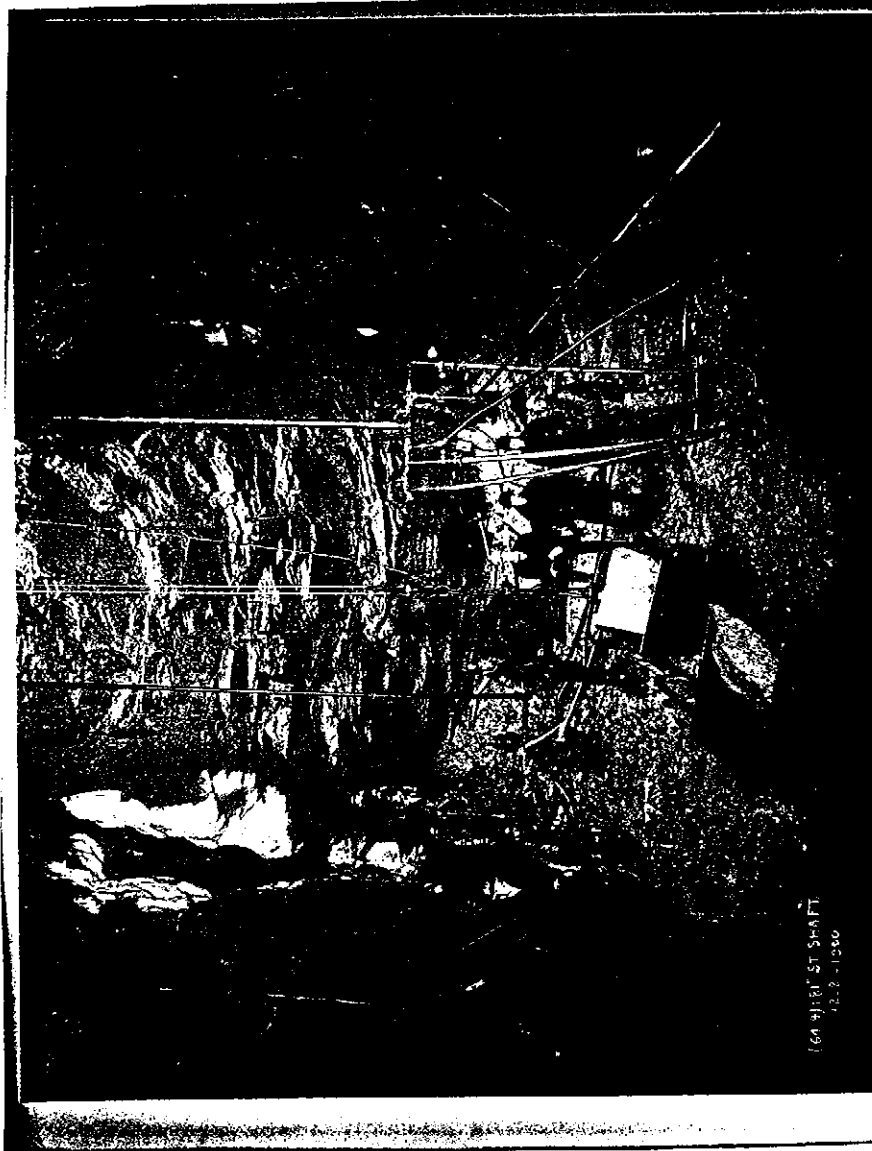
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Photocopied August 1978. (B)
EXCAVATION AT BROADWAY AND 158TH STREET. SOUTH
PORTAL OF TWO-MILE LONG HARD ROCK TUNNEL TO FORT GEORGE.
OCTOBER 2, 1900.



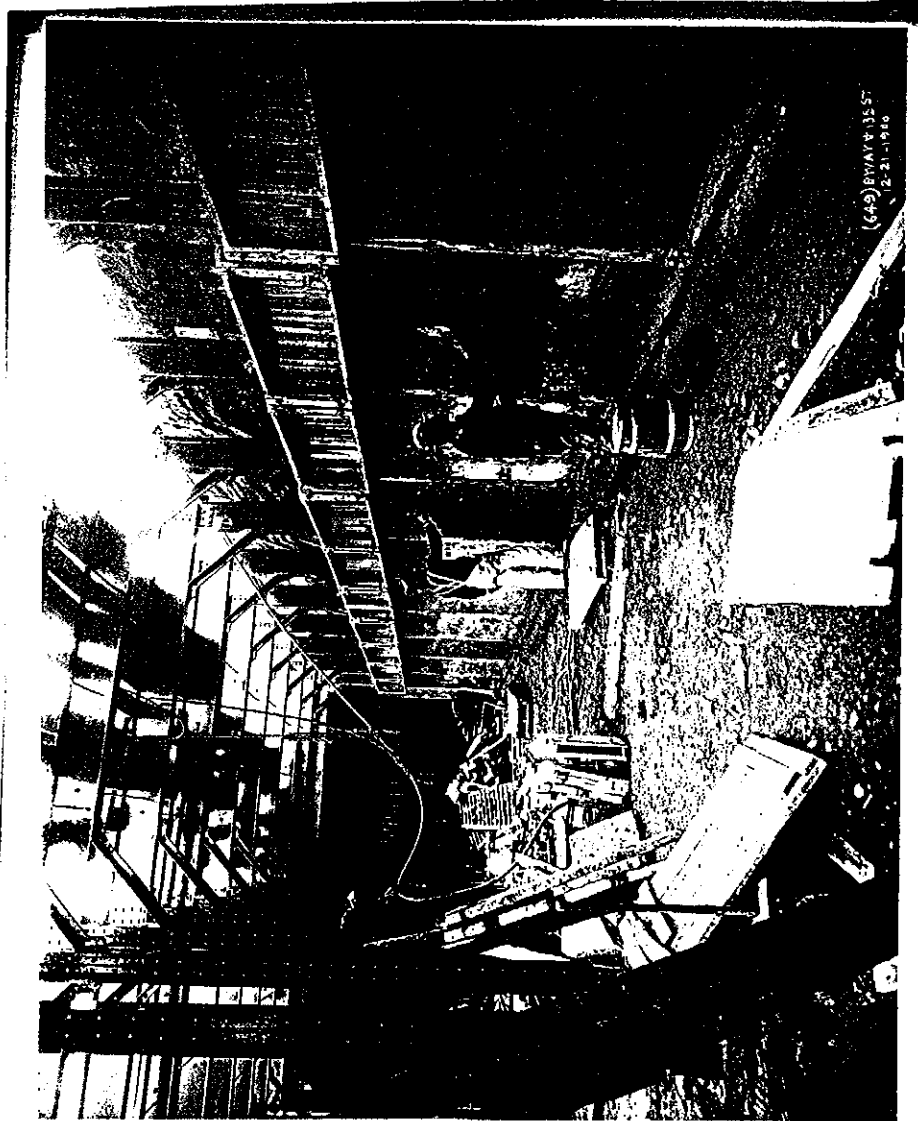
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Photocopied August 1978. (B)
WORKMEN TURNING BRICK ARCH ON 110TH STREET SEWER.
OCTOBER 22, 1900.



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Photocopied August 1978. (B)
WORKMEN AND EQUIPMENT AT 181ST STREET SHAFT SUNK IN
ROCK. NOTE PIPES FOR SUPPLYING COMPRESSED AIR TO
ROCK DRILLS AND PUMPS. DECEMBER 21, 1900.



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Photocopied August 1978. (B)
WORKMEN PATCHING CONCRETE WALLS AT BROADWAY AND 135TH
STREET. NOTE WOODEN MOLDS FOR FORMING CONCRETE ARCH
WALLS BETWEEN STEEL BEAM COLUMNS. DECEMBER 21, 1900.



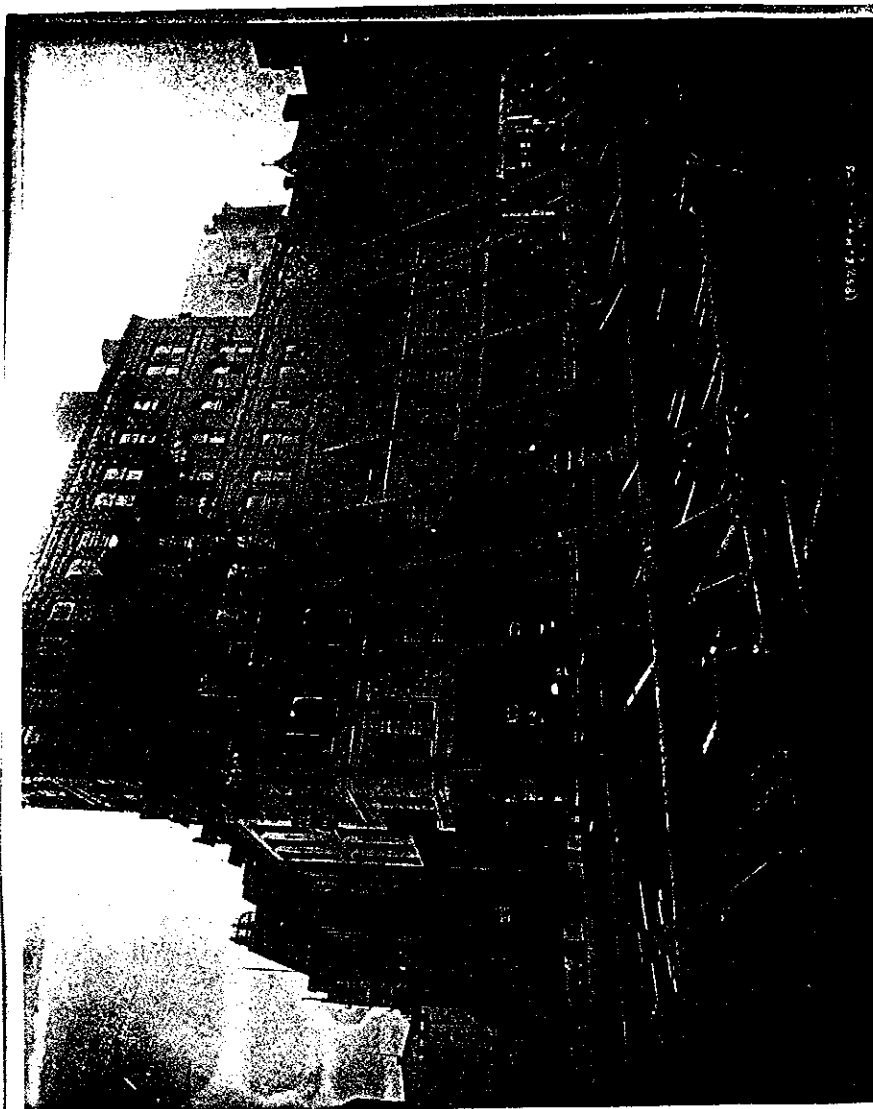
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Photocopied August 1978. (B)
TUNNEL HEADING IN STONE AT 181ST STREET.
MARCH 3, 1901.



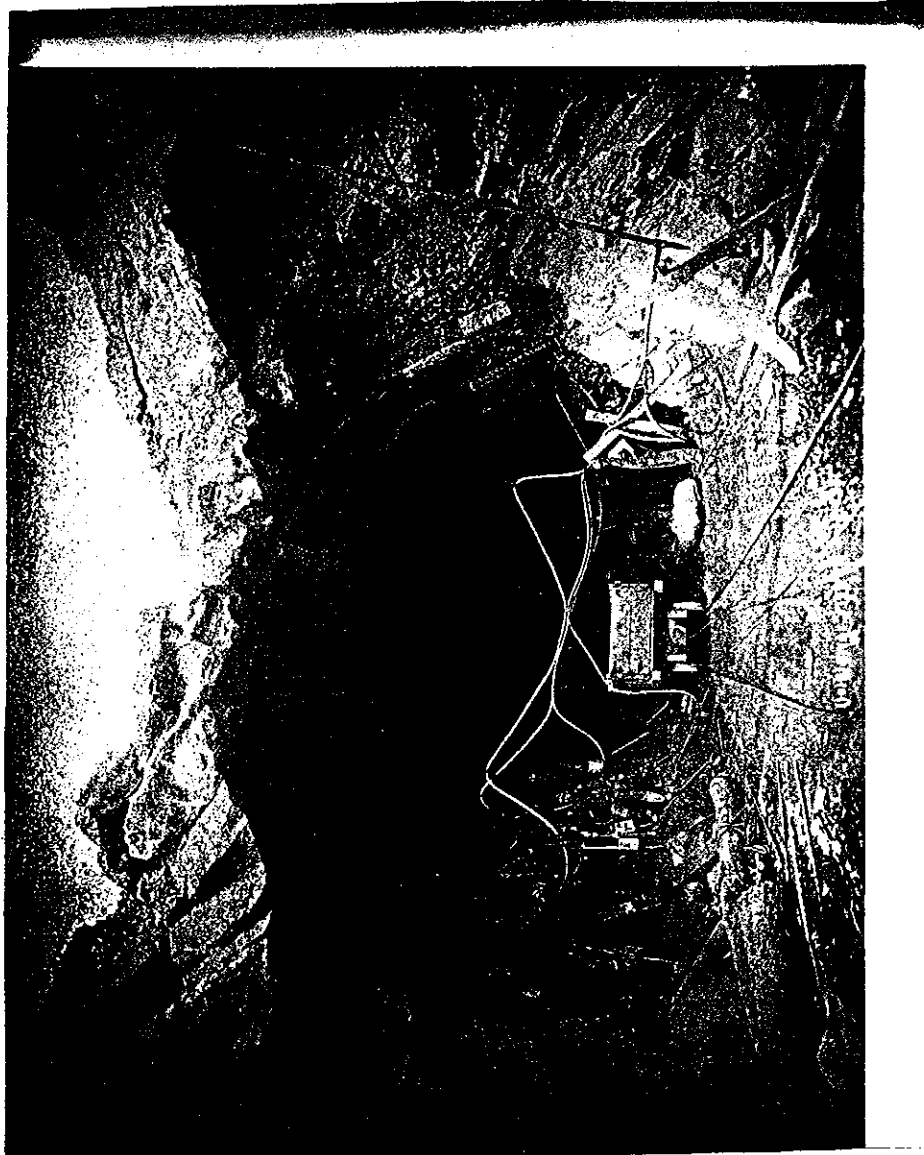
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Photocopied August 1978. (B)
LARGE ARCH CENTERING FORM FOR CONCRETE FOR TWO-TRACK
ARCH TUNNEL BUILT IN OPEN EXCAVATION. MARCH 13, 1901.



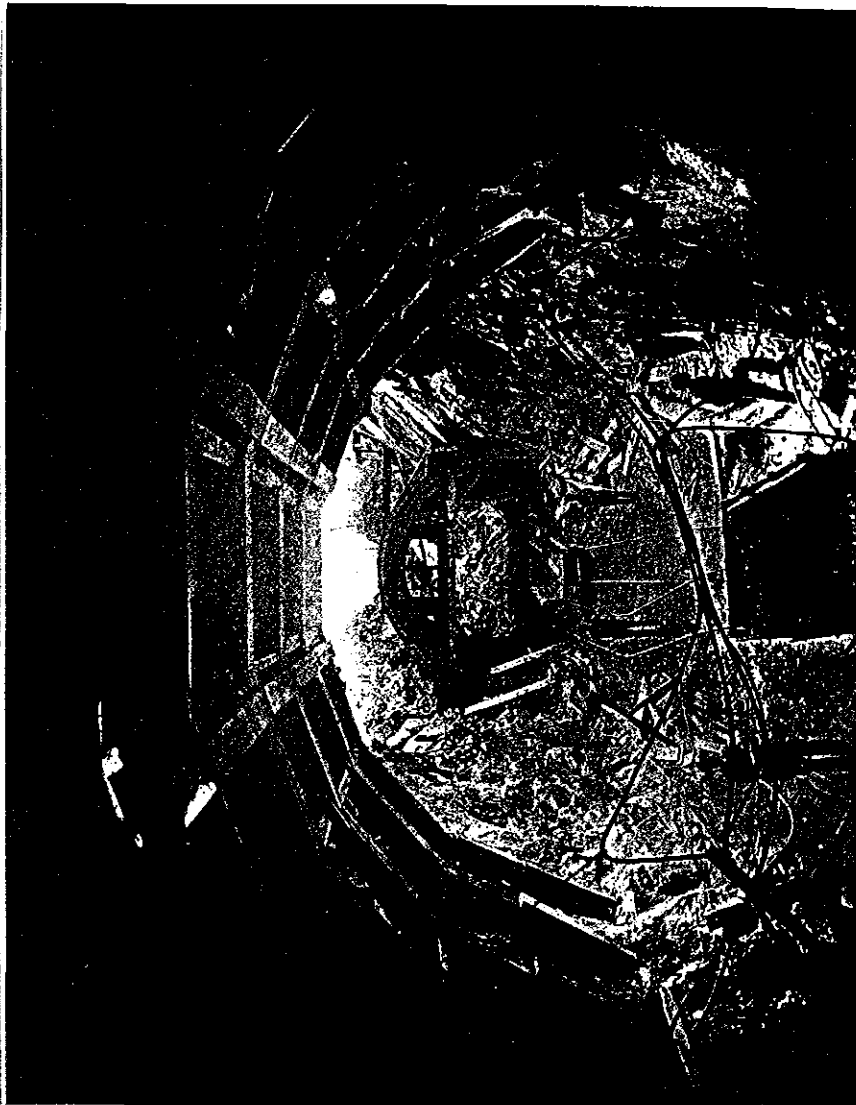
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Photocopied August 1978. (B)
SHORING AND BRACING OF MASONRY STRUCTURE ADJACENT TO
EXCAVATION AT ELM AND BOND STREETS.



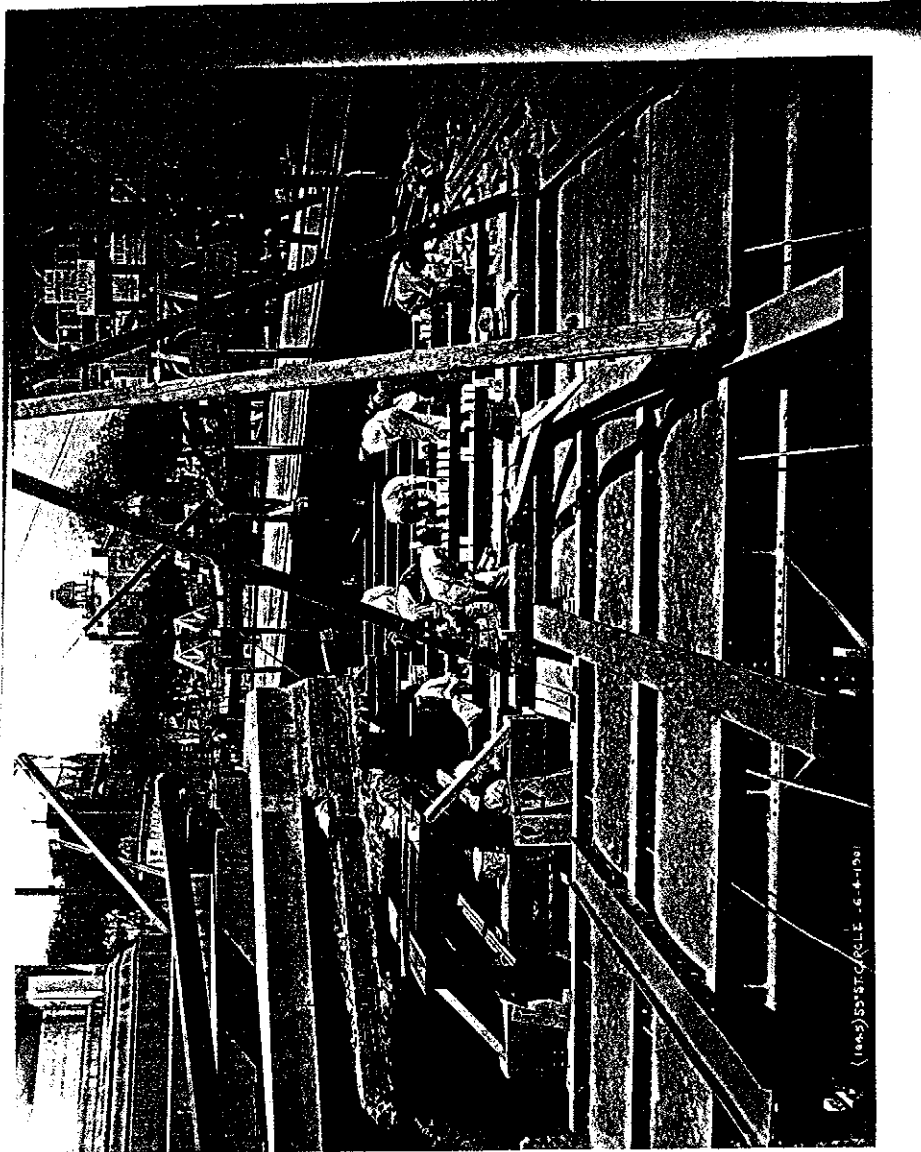
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Photocopied August 1978. (B)
WORKMEN AT TUNNEL END AT BROADWAY AND 158TH STREET.
SOUTH PORTAL OF TWO-MILE, HARD-ROCK TUNNEL (158TH TO
FORT GEORGE). MARCH 15, 1901.



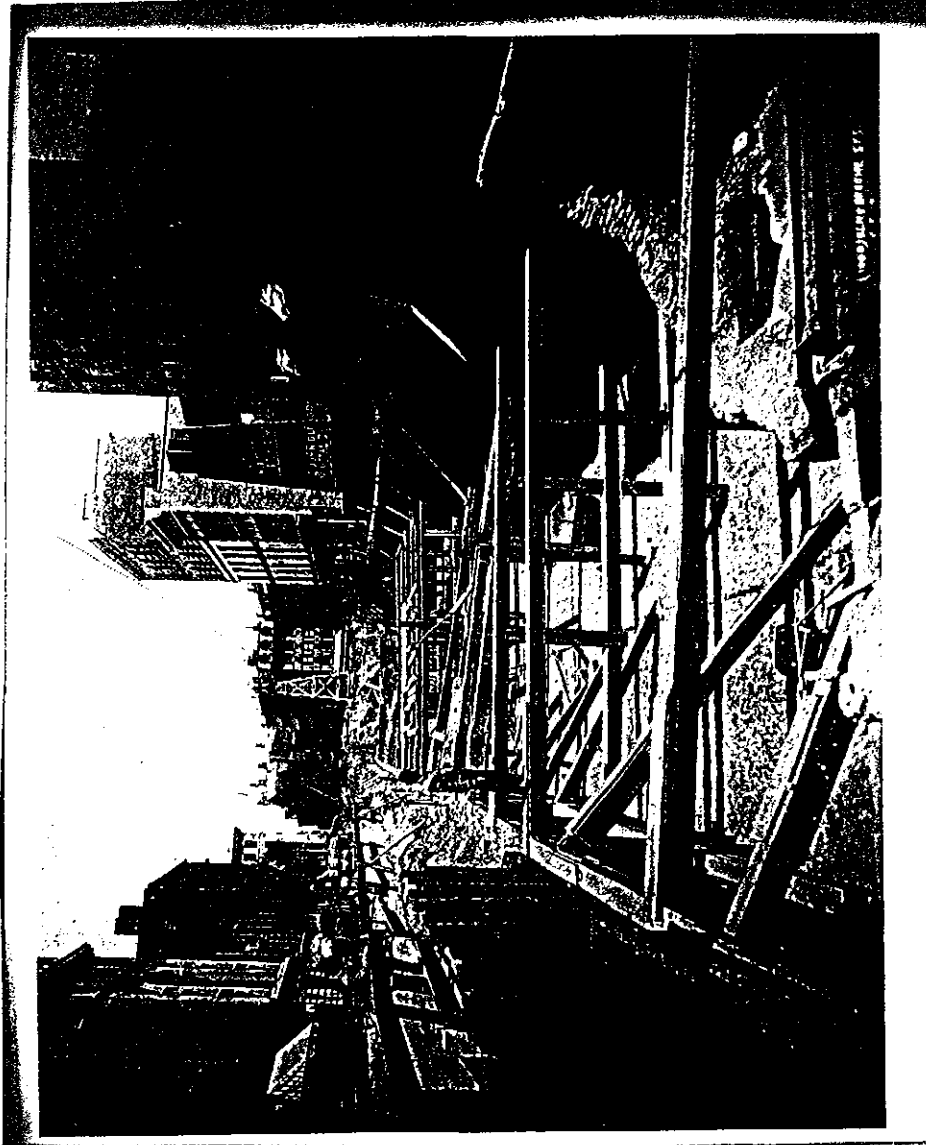
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
VIEW LOOKING SOUTH SHOWING TRANSITION FROM TUNNEL TO
OPEN CUT EXCAVATION AT BROADWAY AND 158TH STREET.
NOTE PORTION OF COMPLETED CONCRETE ARCH ROOF FOR SUB-
WAY AT CENTER.



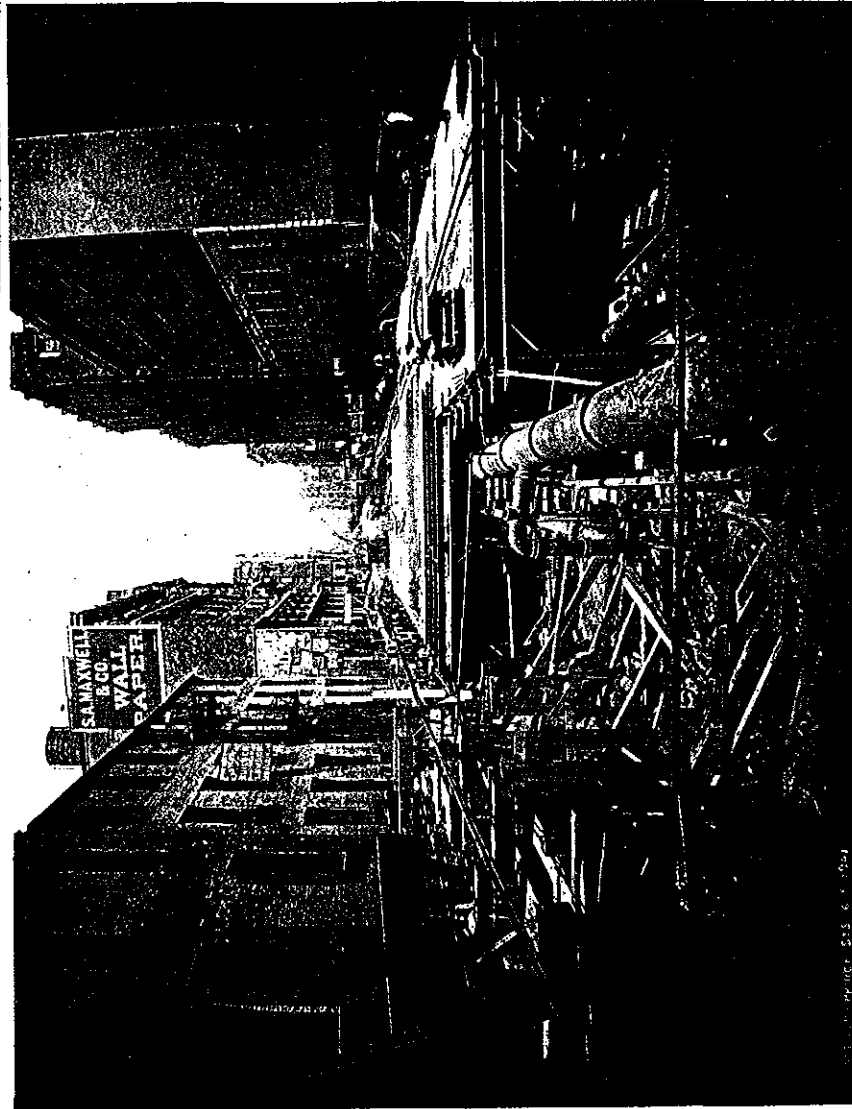
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Photocopied August 1978. (B)
CONSTRUCTION BENEATH CHRISTOPHER COLUMBUS STATUE AT
59TH STREET CIRCLE. NOTE TEMPORARY STEEL UNDERPINNING
BENEATH MONUMENT AT LEFT. JUNE 4, 1901.



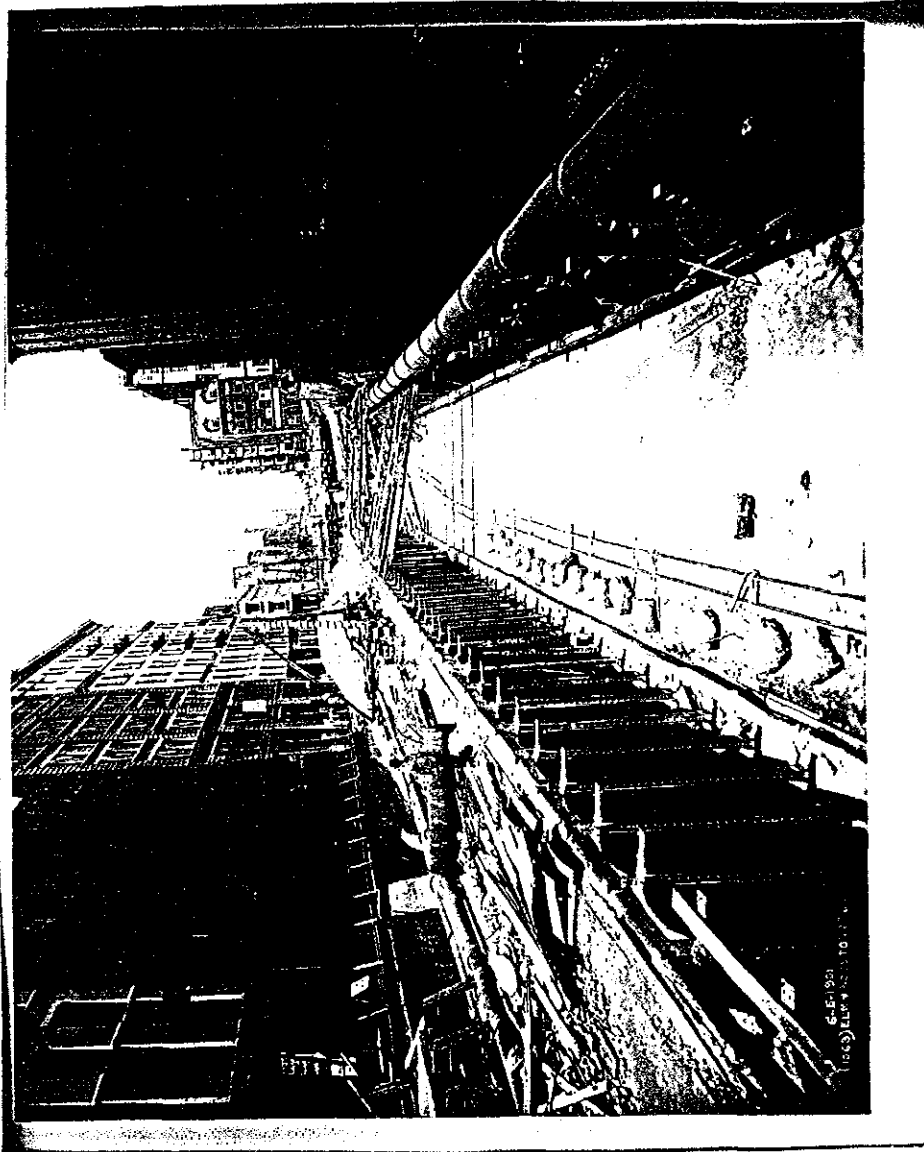
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Photocopied August 1978. (8)
EXCAVATION THROUGH SAND AT ELM AND BROOME STREETS.
JUNE 5, 1901.



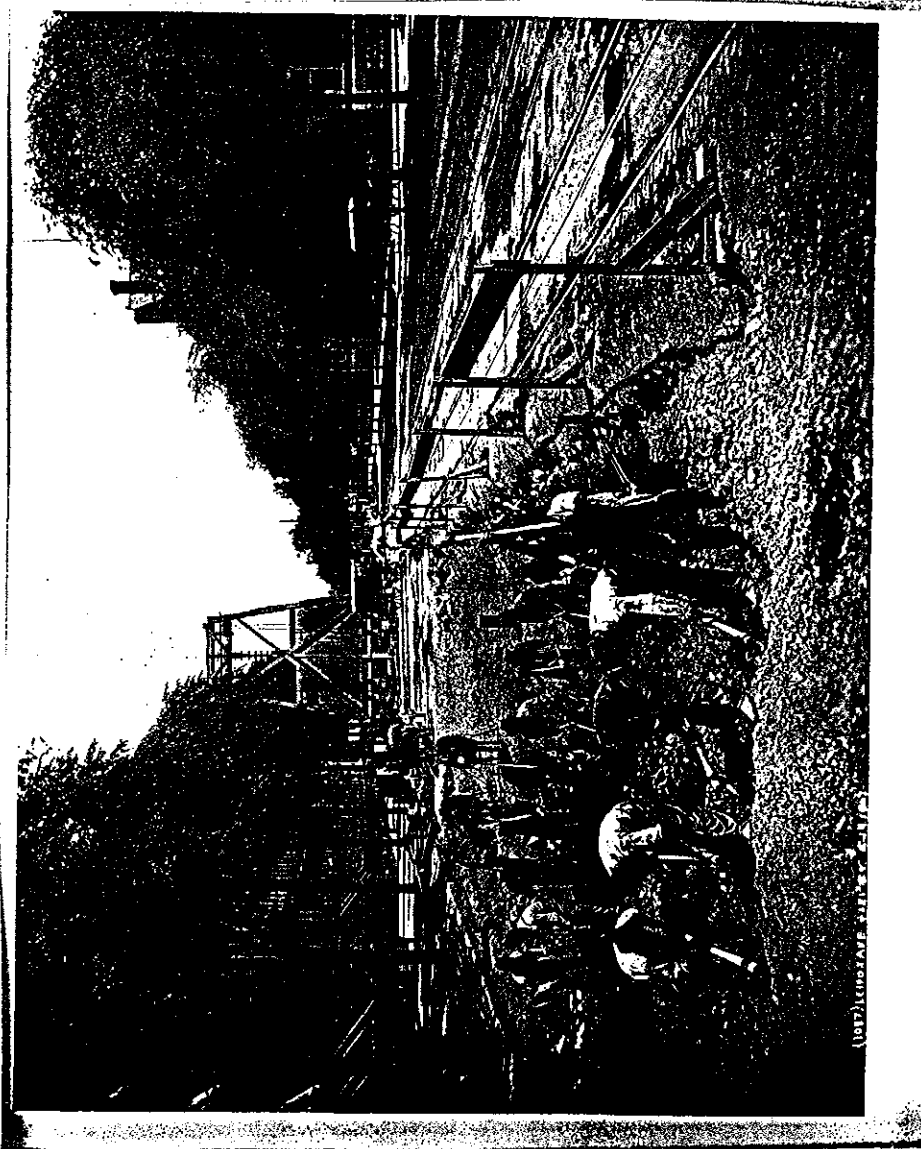
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Photocopied August 1978. (B)
EXCAVATION AND STEELWORK AT ELM AND PRINCE STREETS.
JUNE 5, 1901.



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Photocopied August 1978. (B)
EXCAVATION AND STEELWORK AT ELM AND HOUSTON STREETS.
ILLUSTRATES CONSTRUCTION OF ONE HALF (TWO TRACKS) OF
SUBWAY AT A TIME. JUNE 5, 1901.



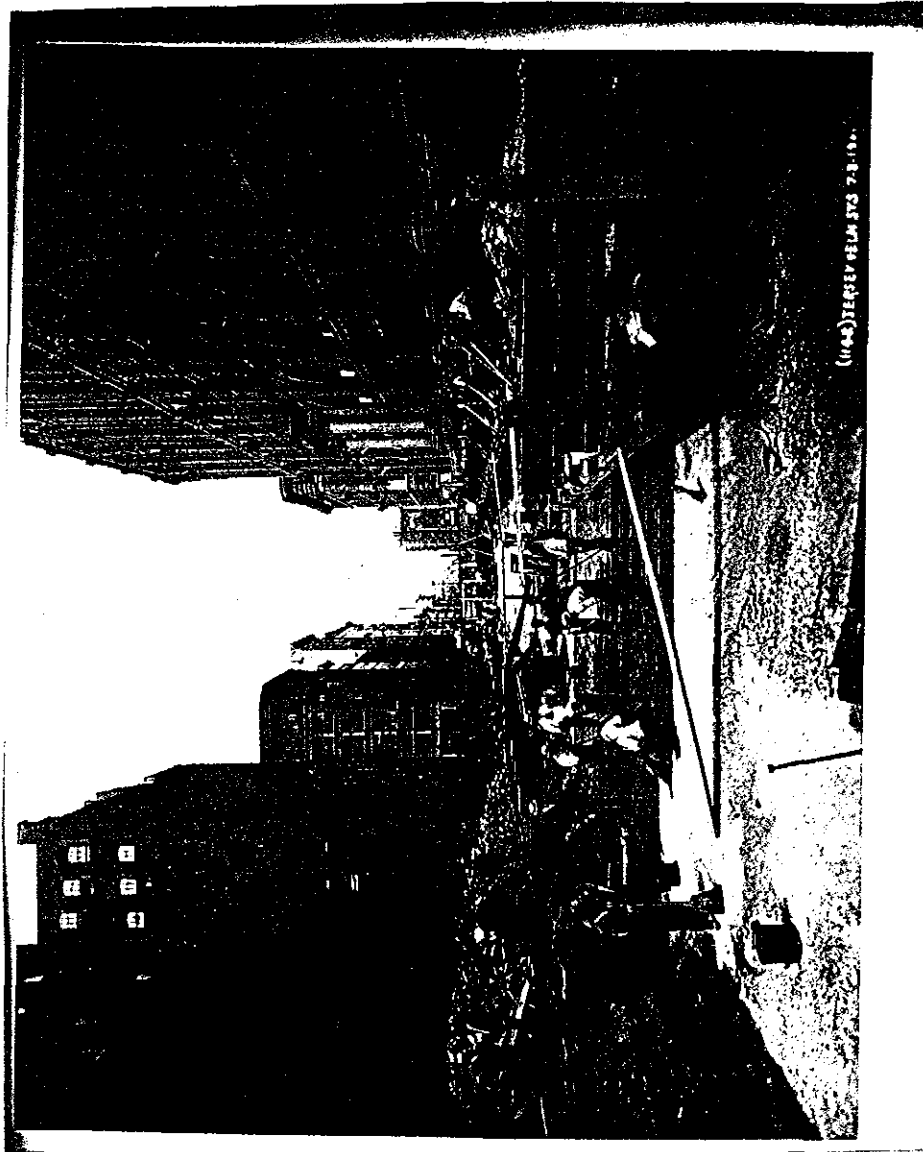
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
MEN EXCAVATING WITH PICKS AT LENOX AVENUE AND 121ST
STREET. JUNE 13, 1901.



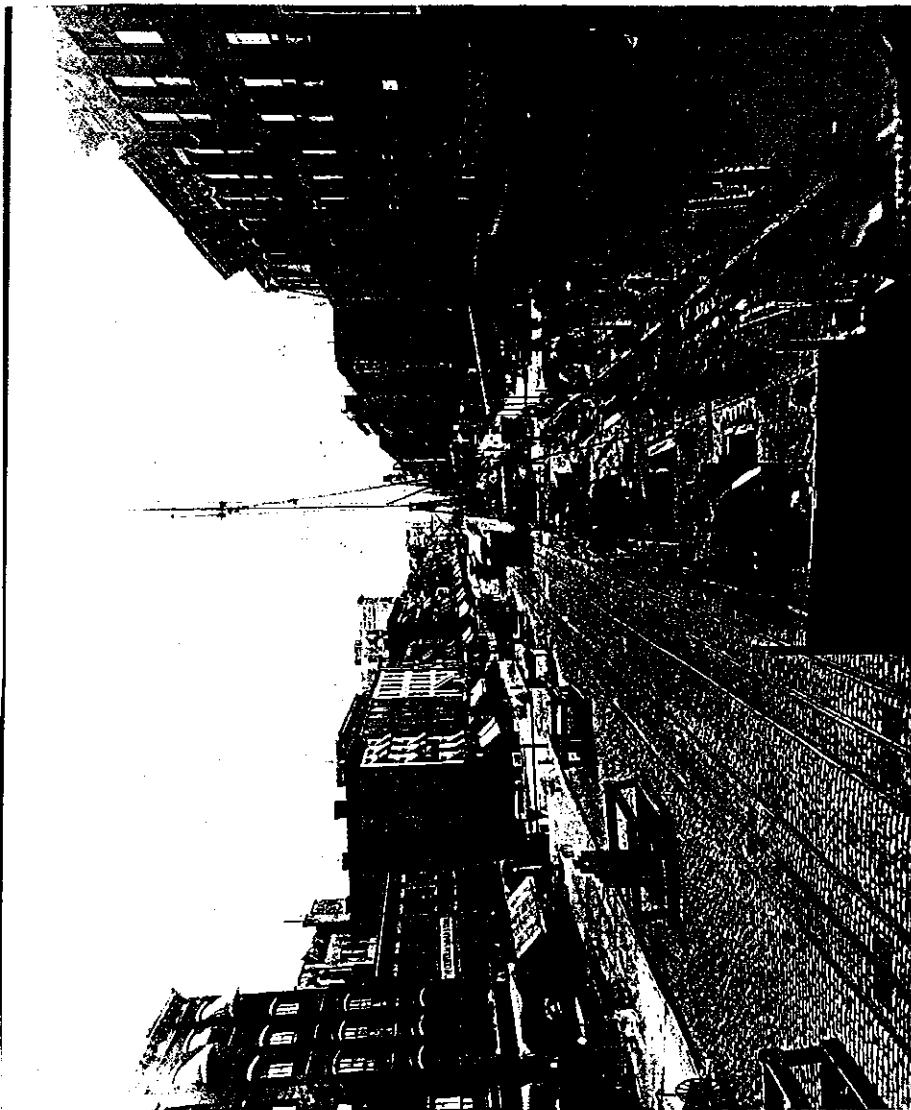
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Photocopied August 1978. (B)
EXCAVATION AND TIMBER SUPPORTS (SHEET PILING AND
CROSS BRACES) AT BRYANT PARK. WORKERS AT LEFT CON-
STRUCTING EXTERIOR WALL USING HOLLOW CORE BLOCK.
JUNE 27, 1901.



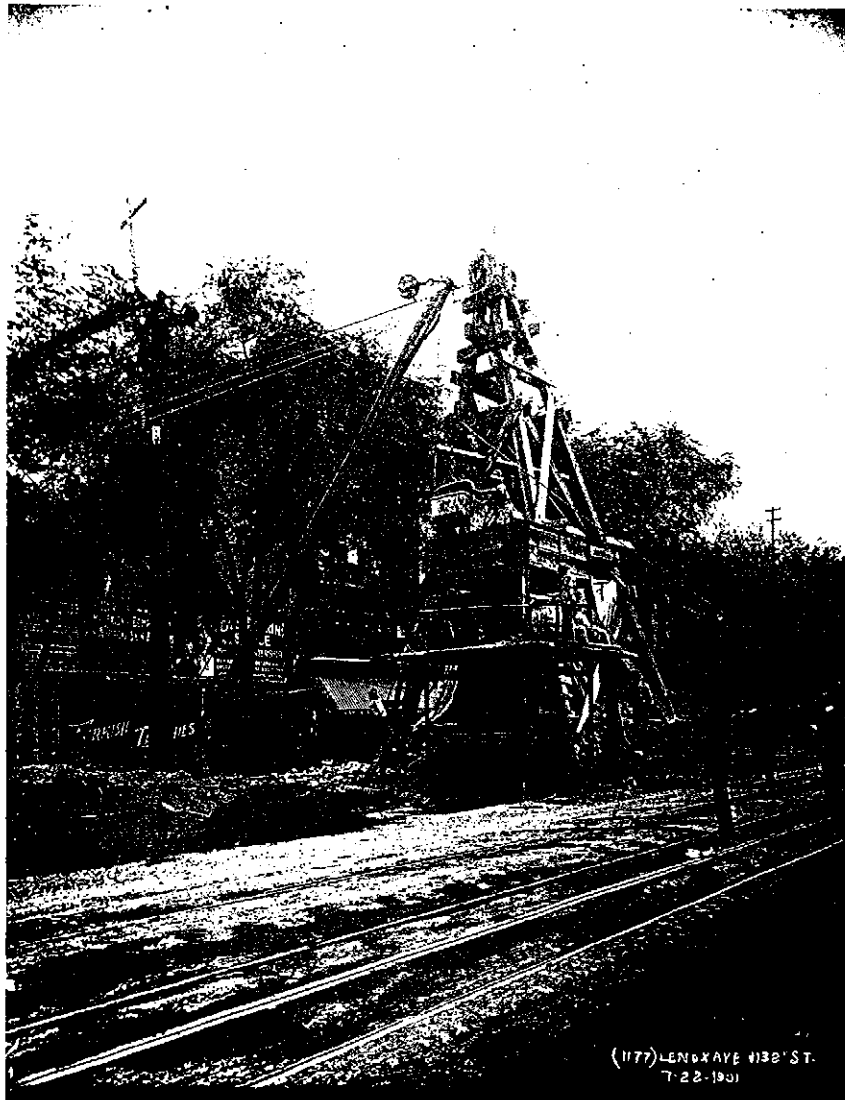
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
WORKMEN LAYING WATER-PROOFING MATERIAL ON ROOF OF
SUBWAY AT JERSEY AND ELM STREETS BEFORE BACKFILLING
AND RECONSTRUCTING STREET. JULY 8, 1901.



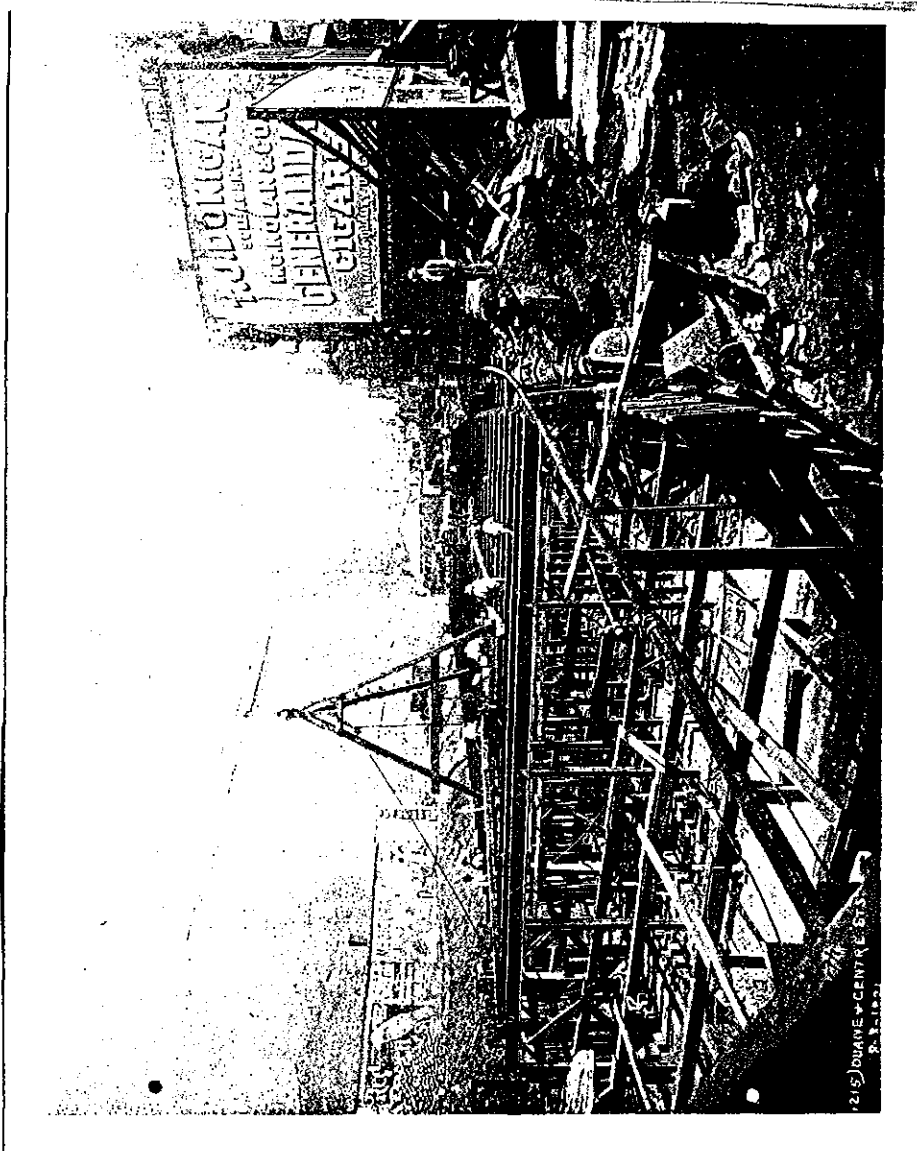
Photocopy of photograph. Copyright held by the New York Historical Society,
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Photocopied August 1978. (B)
EXCAVATION BENEATH 4TH AVENUE WITHOUT DISRUPTING
STREET SURFACE. JULY 9, 1901.



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Photocopied August 1978. (B)
CABLE-WAY, TOWER, BUCKET AND CART FOR REMOVAL OF EXCA-
VATED MATERIALS AT LENOX AVENUE AND 132ND STREET.
JULY 22, 1901.



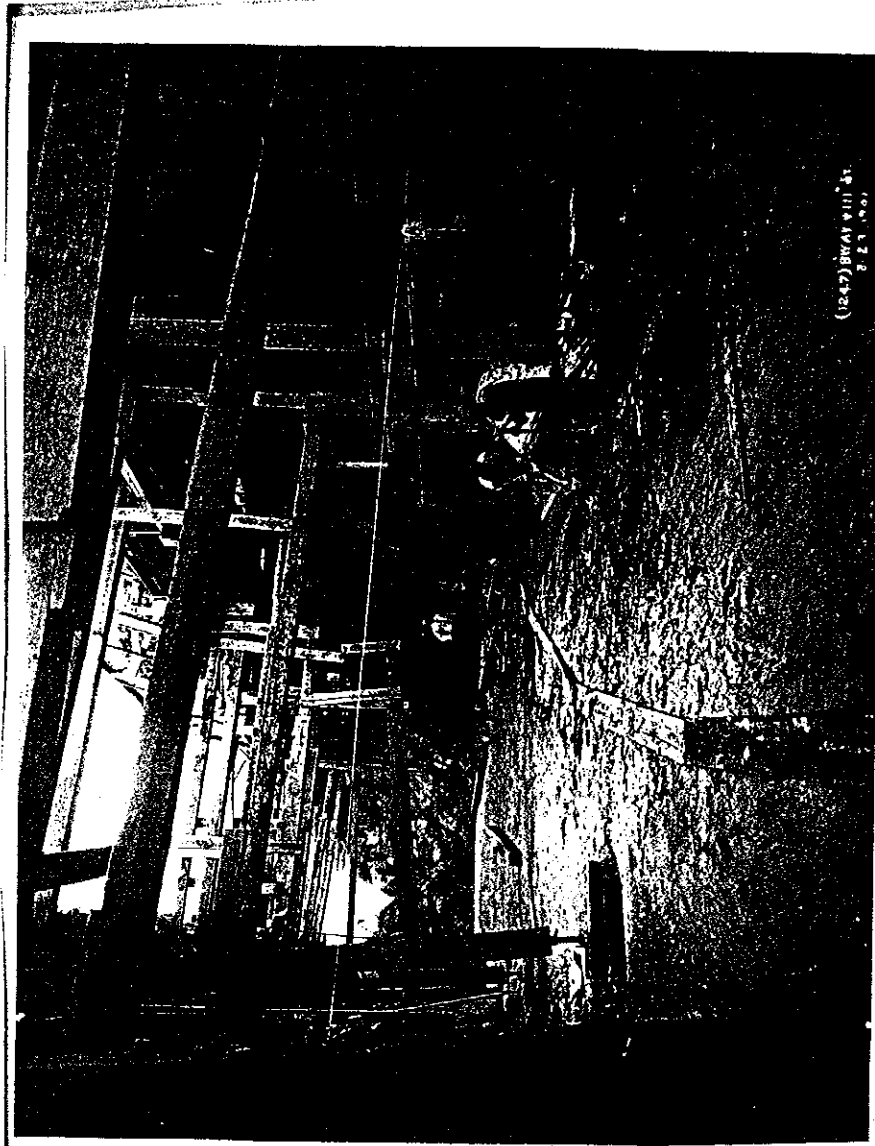
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Photocopied August 1978. (B)
ERECTION STEELWORK AT DUANE AND CENTRE STREETS.
AUGUST 8, 1901.



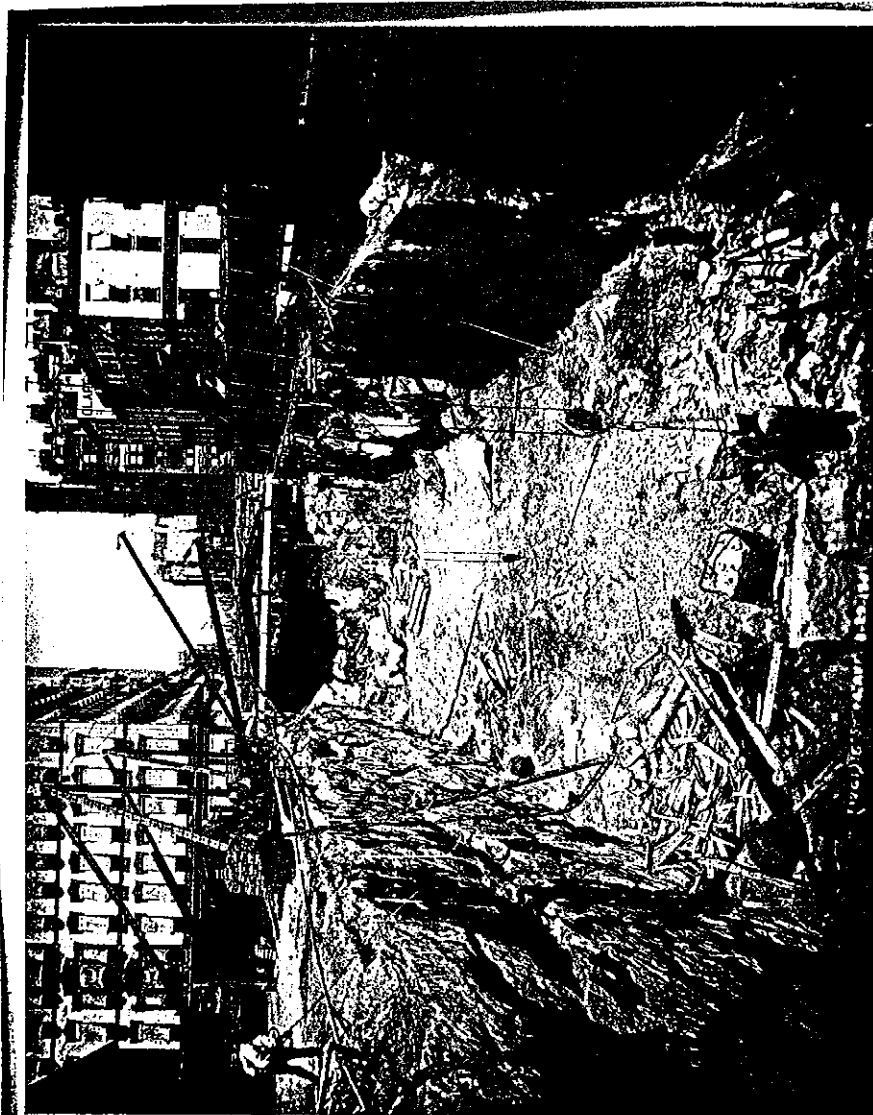
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Photocopied August 1978. (B)
CABLE-WAY AND BUCKETS FOR REMOVING EXCAVATED MATERIAL
AT 11TH STREET AND 4TH AVENUE.



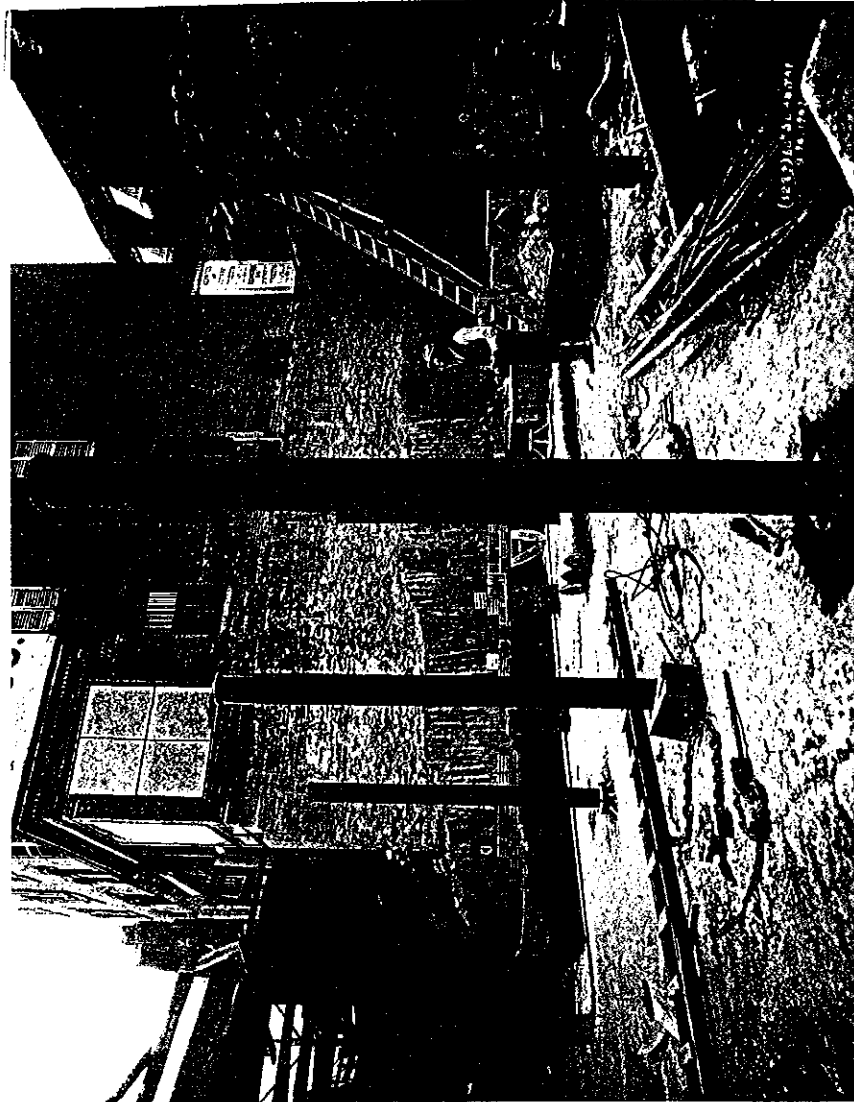
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Photocopied August 1978. (B)
LAYING OF CONCRETE FLOOR AT BROADWAY AND 111TH
STREET. AUGUST 23, 1901.



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Photocopied August 1978. (B)
OPEN CUT IN ROCK AT 16TH STREET AND 4TH AVENUE.
AUGUST 29, 1901



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Photocopied August 1978. (8)
EARLY STAGES OF CONSTRUCTION OF STATION AT BROADWAY
AND 50TH STREET. COLUMNS ARE CAST IRON.
SEPTEMBER 10, 1901.



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Photocopied August 1978. (B)
OPEN CUT AT 4TH AVENUE AND 15TH STREET.
SEPTEMBER 13, 1901.



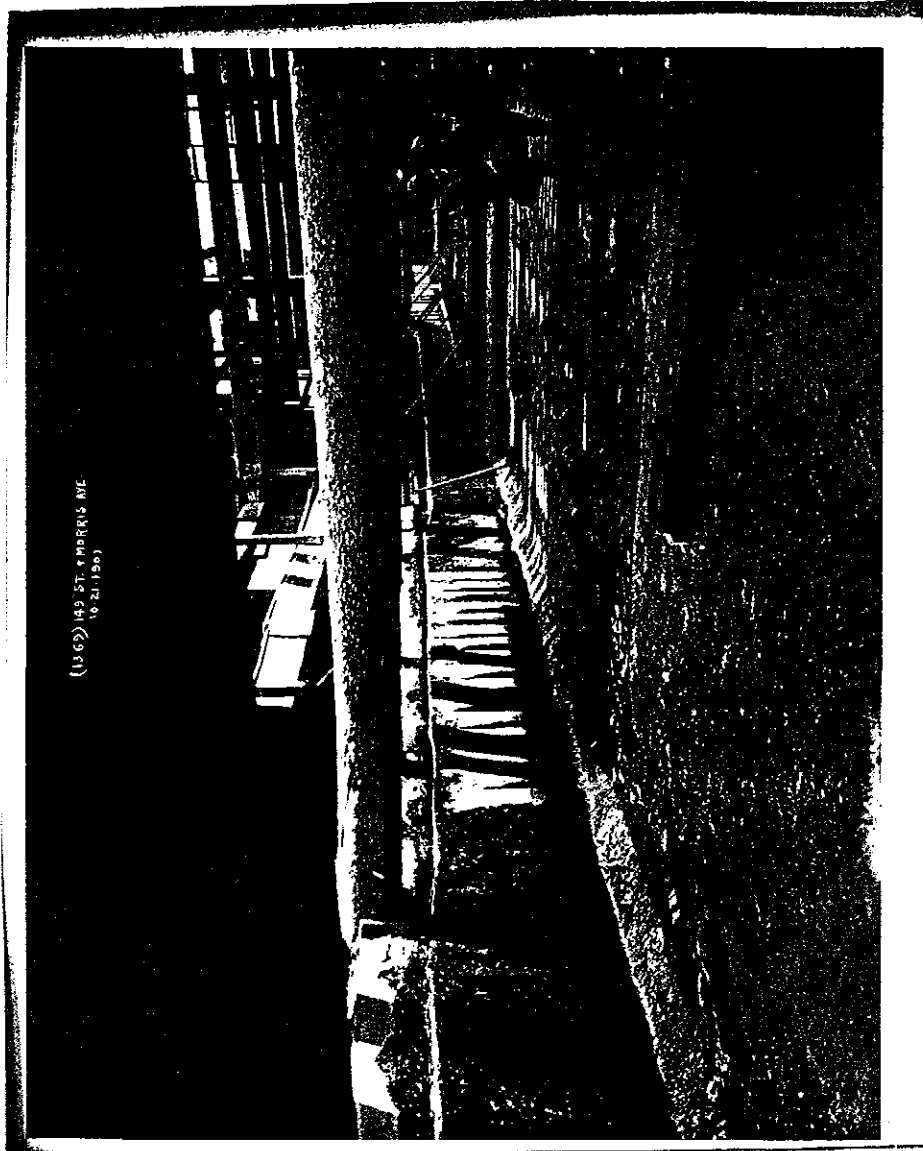
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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
ROCK DRILL IN EXCAVATION AT BROADWAY BETWEEN 44TH
AND 45TH STREETS. OCTOBER 9, 1901.



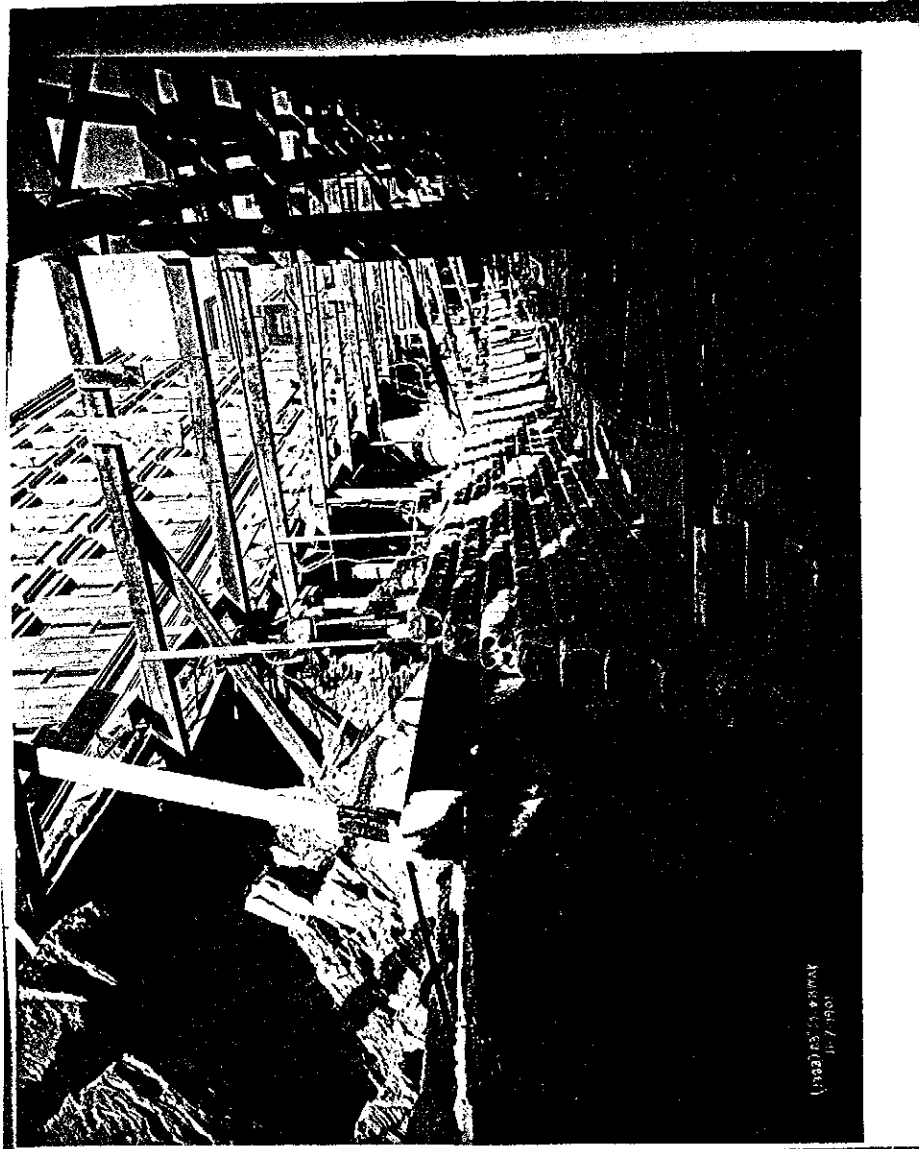
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
POURED CONCRETE SEWER INVERT AT BROADWAY AND 56TH
STREET.



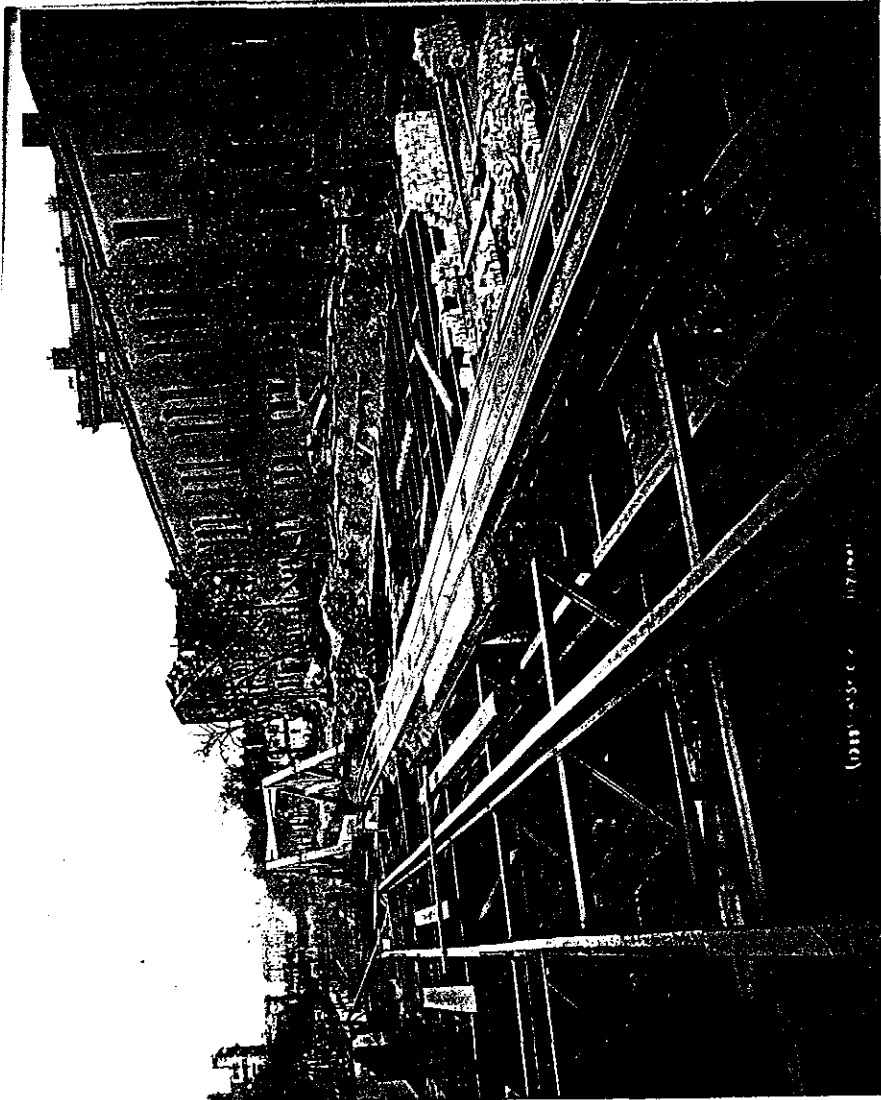
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
LAYERS OF WATERPROOFING PLACED BETWEEN THE TWO LAYERS
OF CONCRETE. OCTOBER 21, 1901.



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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
LAYER OF WATERPROOFING AND "DUCT BLOCK" USED IN CON-
STRUCTING EXTERIOR WALL AT BROADWAY AND 43RD STREET.
NOVEMBER 7, 1901.



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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
STEELWORK AT 59TH STREET STATION (COLUMBUS CIRCLE).
NOTE A-FRAME TRESTLE USED TO CARRY STREET-CAR TRACKS
OVER EXCAVATION. NOVEMBER 7, 1901.



Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
THREE-TRACK CONCRETE ARCH TUNNEL CONSTRUCTED IN OPEN
CUT. NOTE ROCK BACKFILL ABOVE ARCH. JANUARY 6, 1902.



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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
STEELWORK AT 15TH STREET AND 4TH AVENUE.
JANUARY 6, 1902.



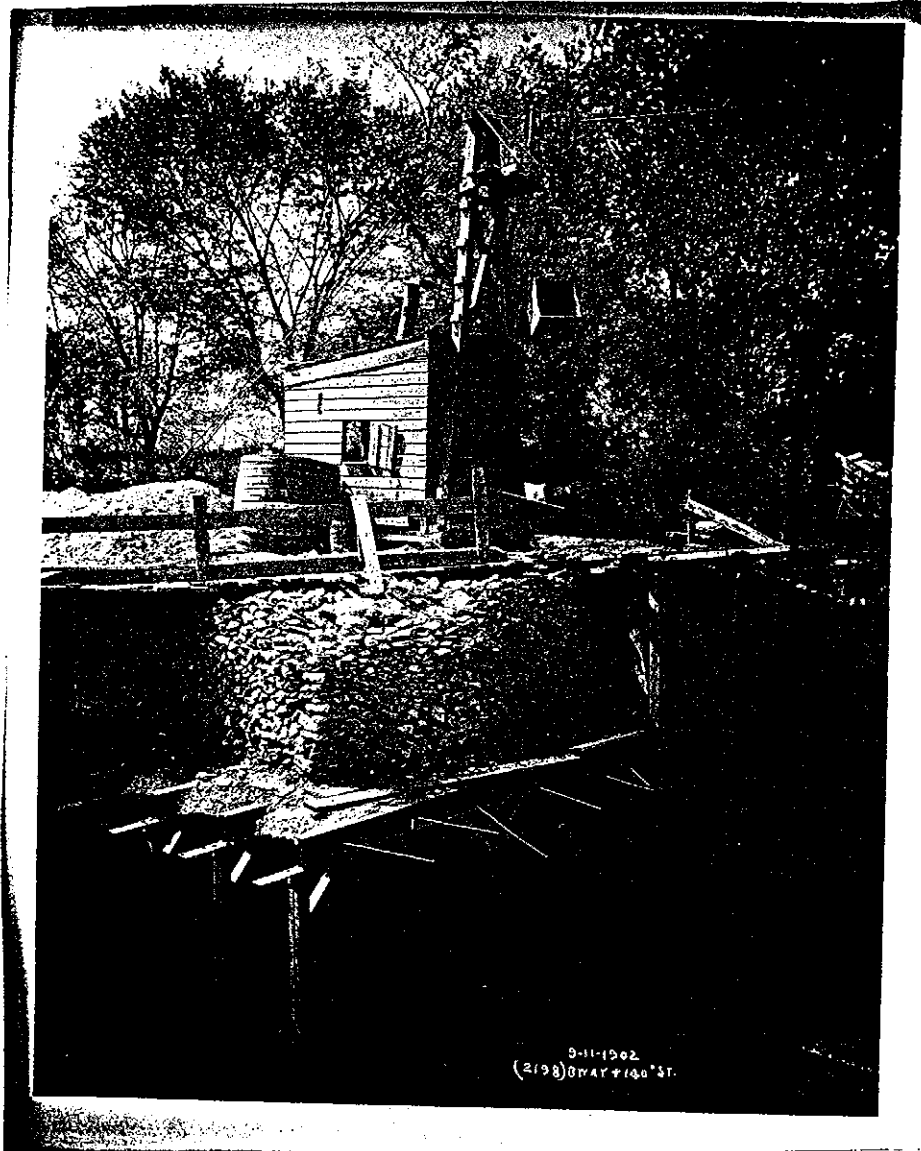
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
STEELWORK AND SIDEWALL CONSTRUCTION AT BROADWAY AND
110TH STREET. NOTE PLACEMENT OF WATERPROOFING BE-
TWEEN BRICK WALL AND CABLE CARRYING CONCRETE BLOCK.
MARCH 11, 1902.



Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
VIEW SHOWING TRANSITION BETWEEN CONCRETE ARCH AND
STEEL FRAME TUNNEL BENEATH CENTRAL PARK.
APRIL 4, 1902.



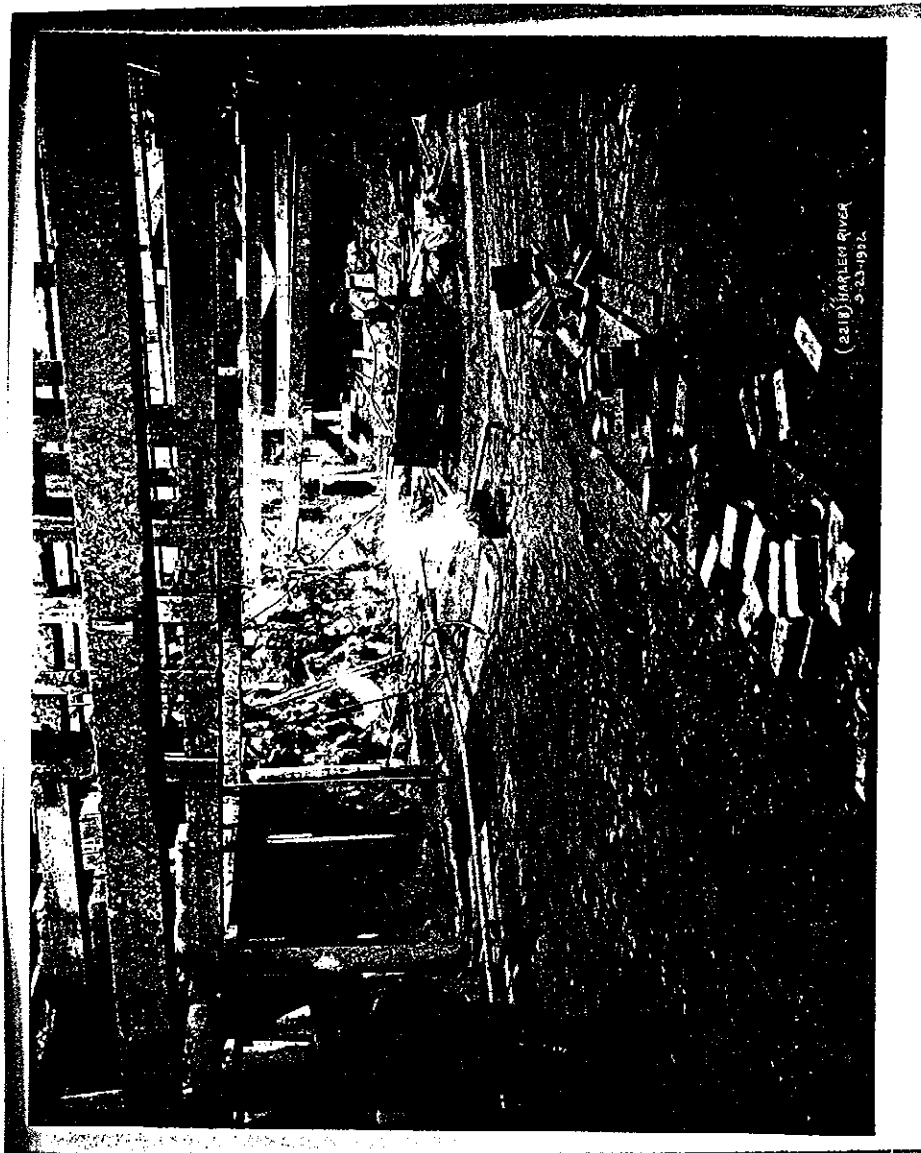
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
VIEW SHOWING ONE-HALF OF EIGHT-TRACK WIDE RIGHT-OF-
WAY BENEATH BROADWAY AND 140TH STREET.
SEPTEMBER 11, 1902.



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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
EXCAVATION AND CONSTRUCTION AT MOTT AVENUE AND 149TH
STREET. SEPTEMBER 23, 1902.



Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
VIEW SHOWING USE OF TWO LAYERS OF BRICK IN HOT ASPHALT
FOR WATERPROOFING GRADIENTS TO HARLEM RIVER TUNNEL.
SEPTEMBER 23, 1902.



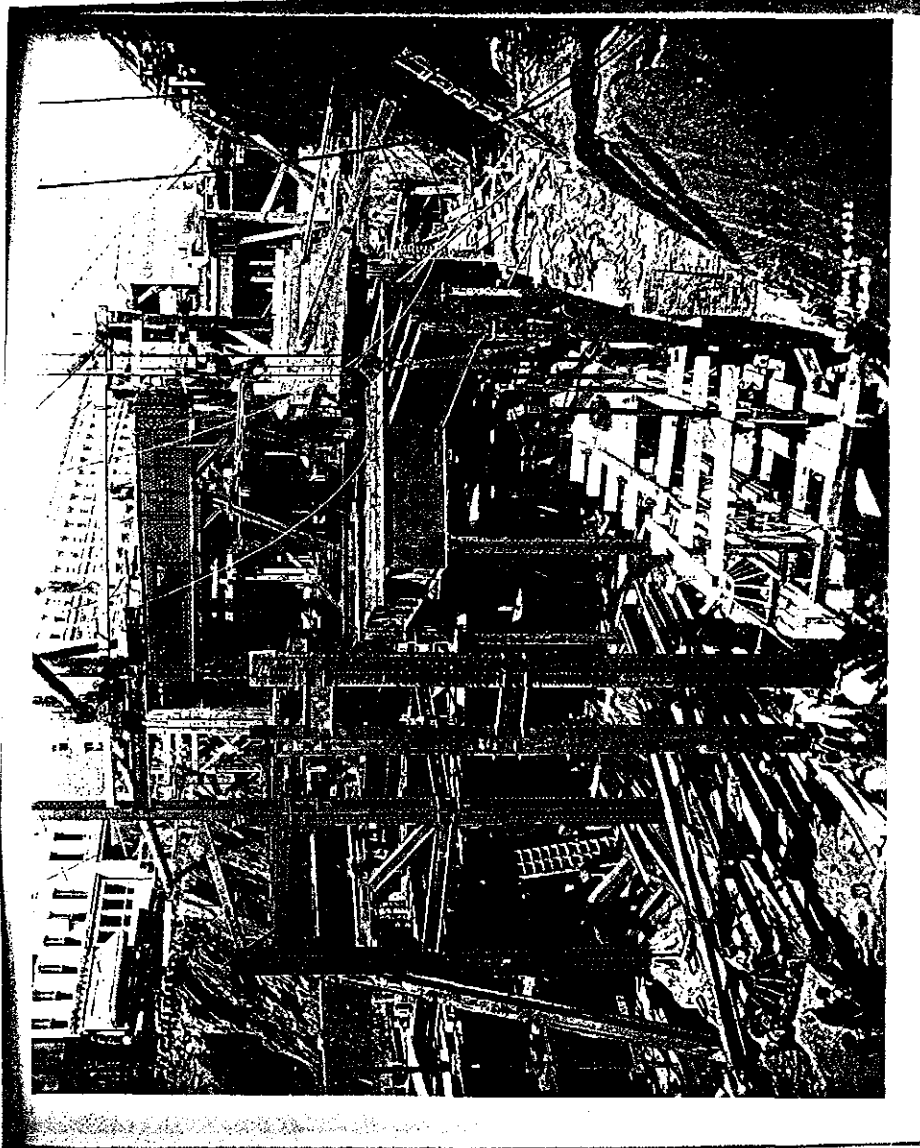
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
EXCAVATION AND ERECTION OF STEELWORK AT 145TH STREET
AND BROADWAY. NOTE GRANITE STONES USED AS FOUND-
ATION FOR STEEL COLUMNS. OCTOBER 15, 1902.



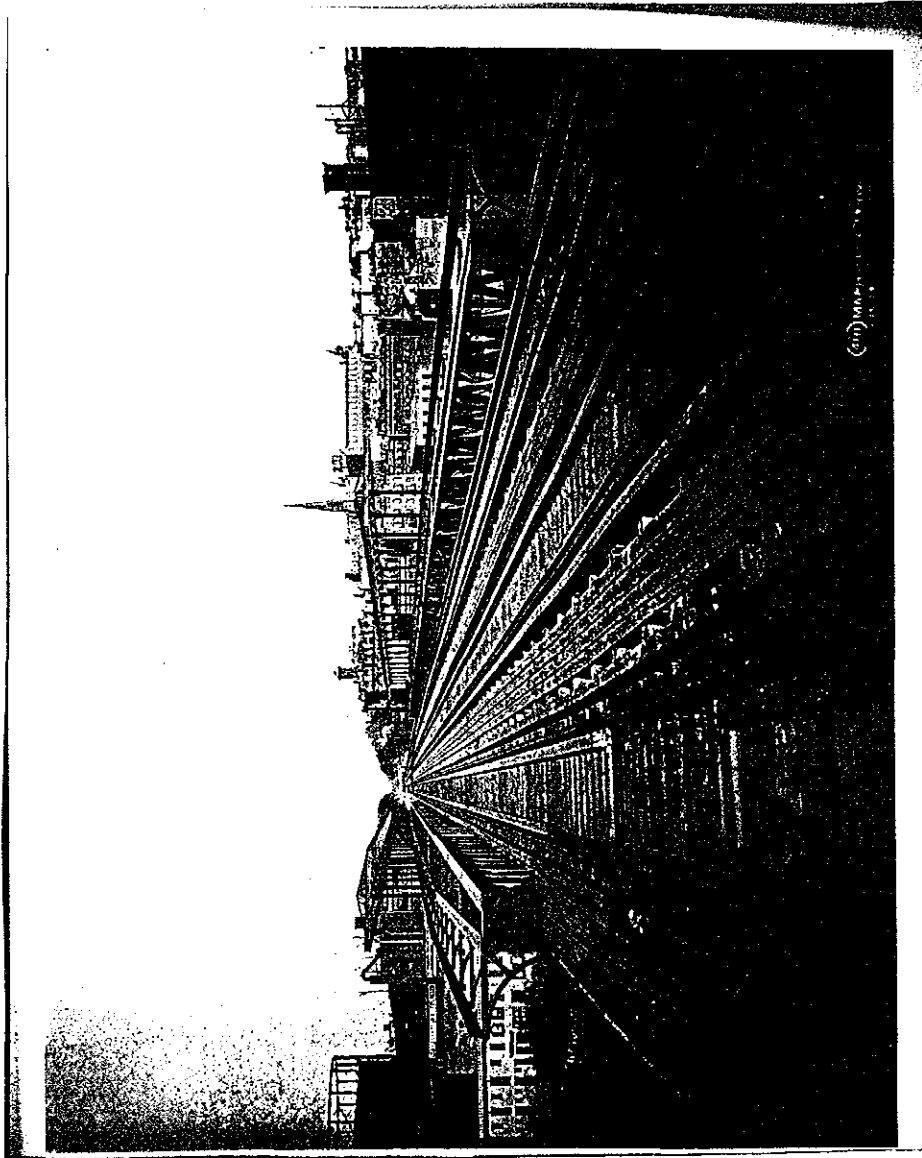
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
EXCAVATION AND ERECTION OF STEELWORK AT 145TH STREET
AND BROADWAY. JANUARY 22, 1903.



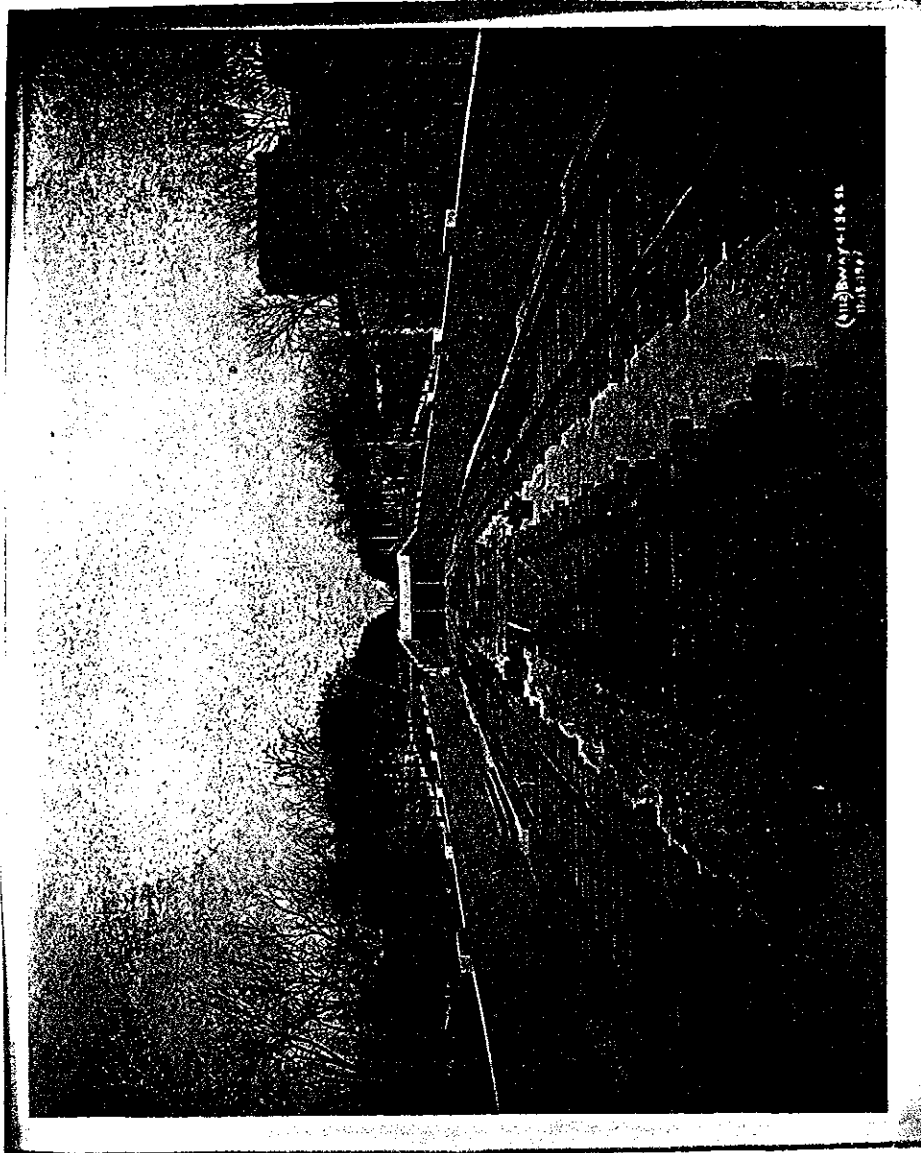
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
STEELWORK FOR SUBWAY BEING ERECTED OVER SPACE TO BE
OCCUPIED BY BASEMENT OF NEW YORK TIMES BUILDING.
NOTE SIGN UPPER RIGHT. SEPTEMBER 25, 1903.



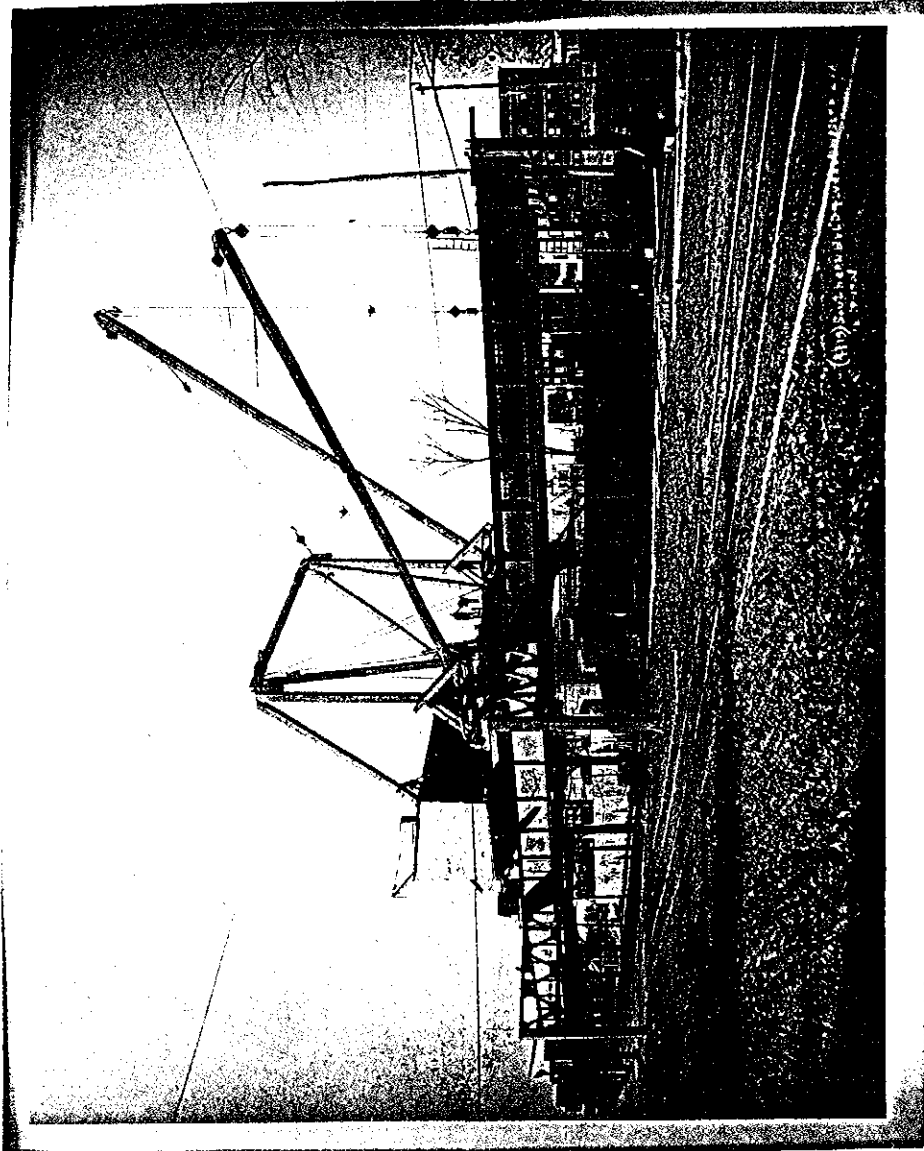
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
ELEVATED TRACKS AND UNFINISHED STATIONS AT MANHATTAN
STREET AND BROADWAY. (LOOKING NORTH)
NOVEMBER 15, 1903.



Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
OPEN TRACKS AND START OF UNDERGROUND SECTION AT
BROADWAY AND 134TH STREET. (LOOKING NORTH)
NOVEMBER 15, 1903.



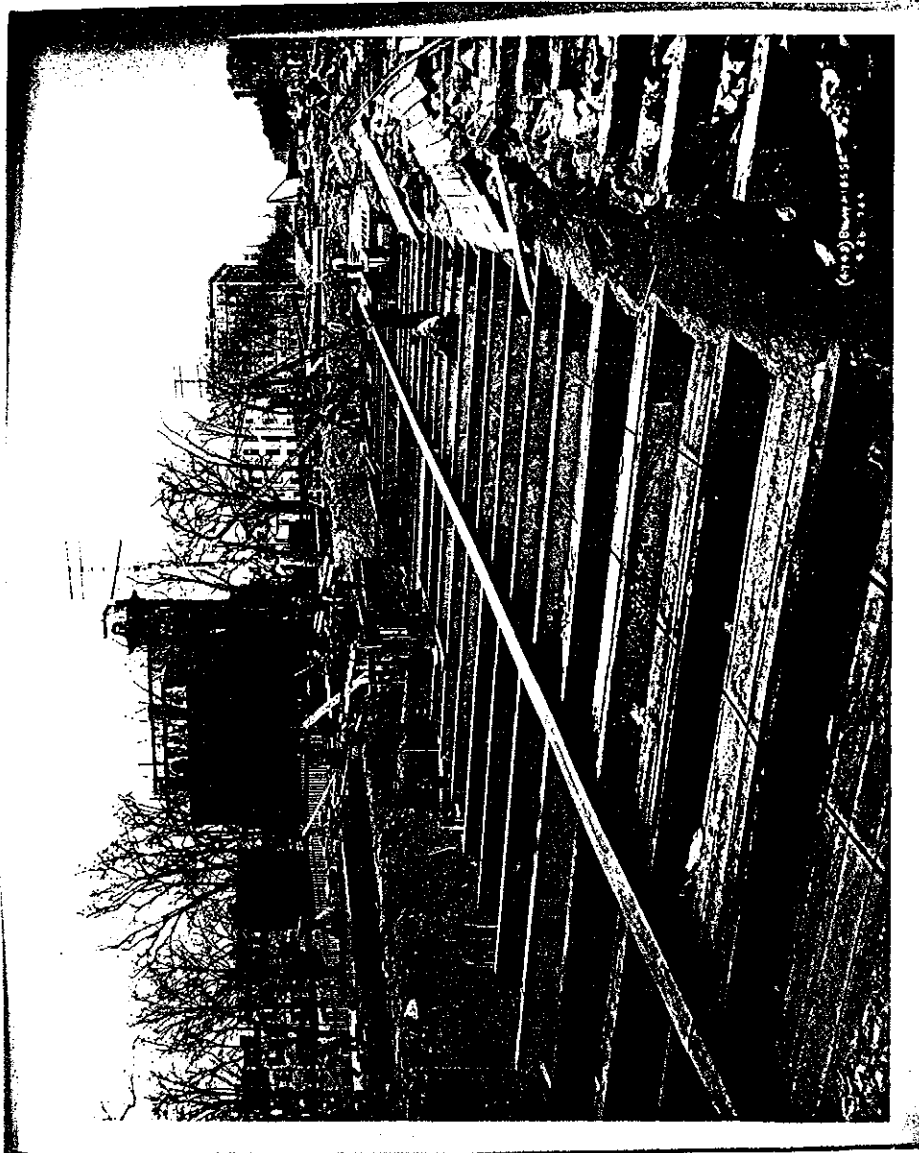
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
ERECTION OF STEEL WORK AND ELEVATED SECTION AT
SOUTHERN BOULEVARD AND WESTCHESTER AVENUE (BRONX).
NOVEMBER 19, 1903.



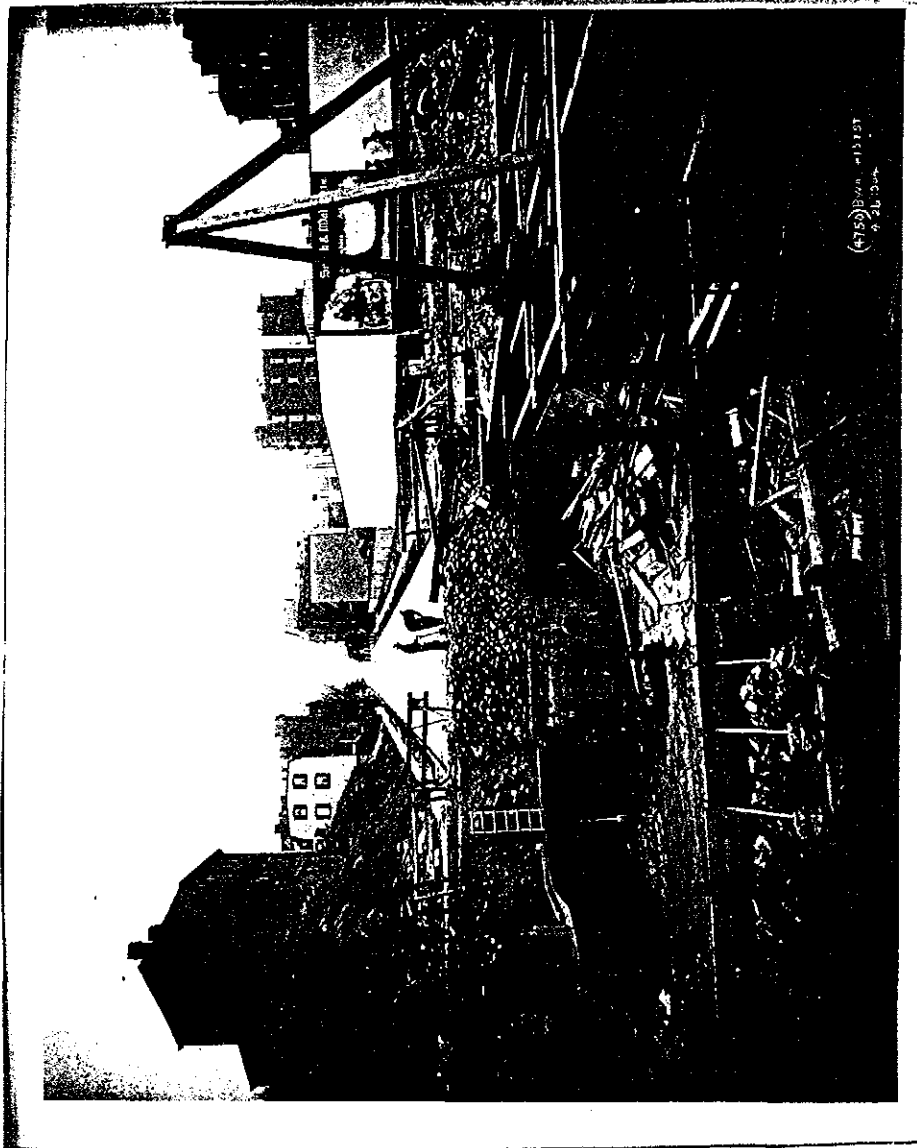
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
EXTERIOR VIEW OF 116TH STREET STATION DURING DIS-
MANTLING. (Courtesy Landmarks Preservation Commission)



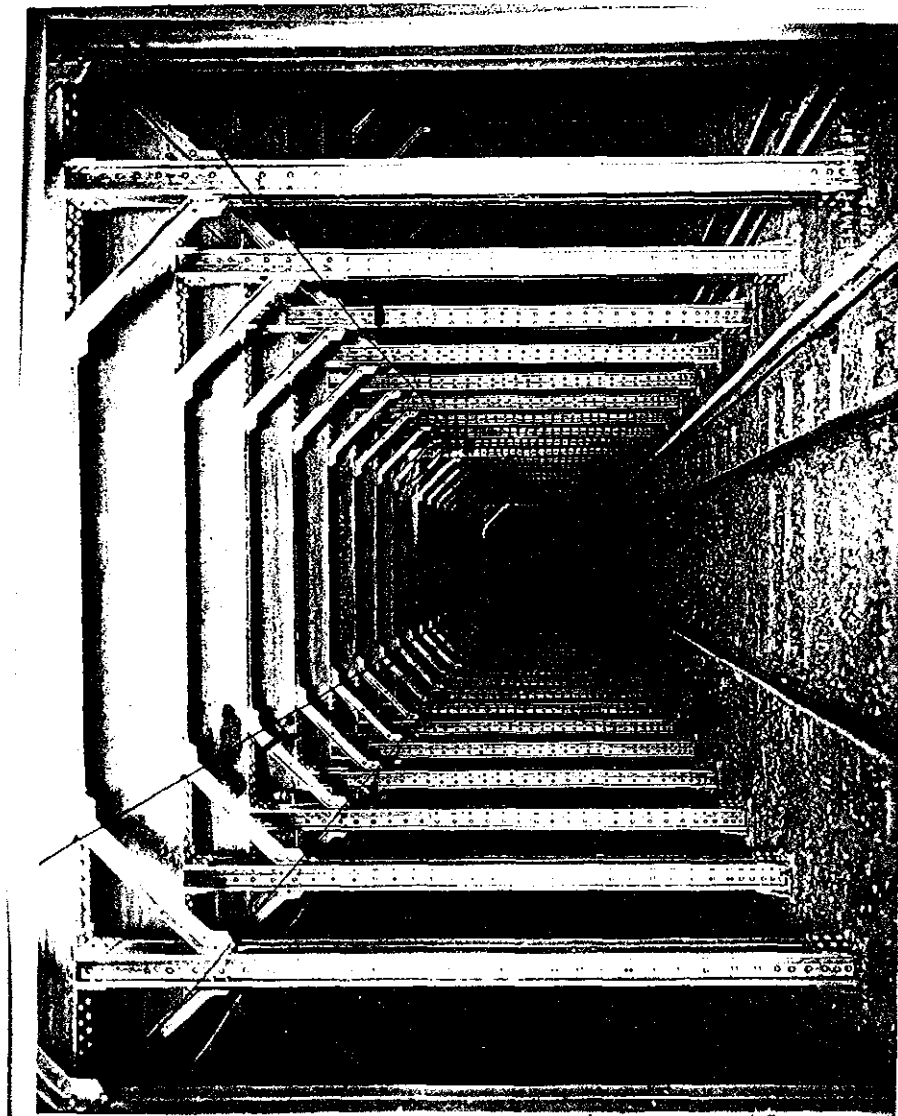
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (8)
STEEL ROOF BEAMS AND FORMS FOR CONCRETE ROOF ARCHES
AT BROADWAY AND 145TH STREET. NOTE STIFFENING STEEL
TIE RODS BETWEEN ROOF BEAMS. APRIL 26, 1904.



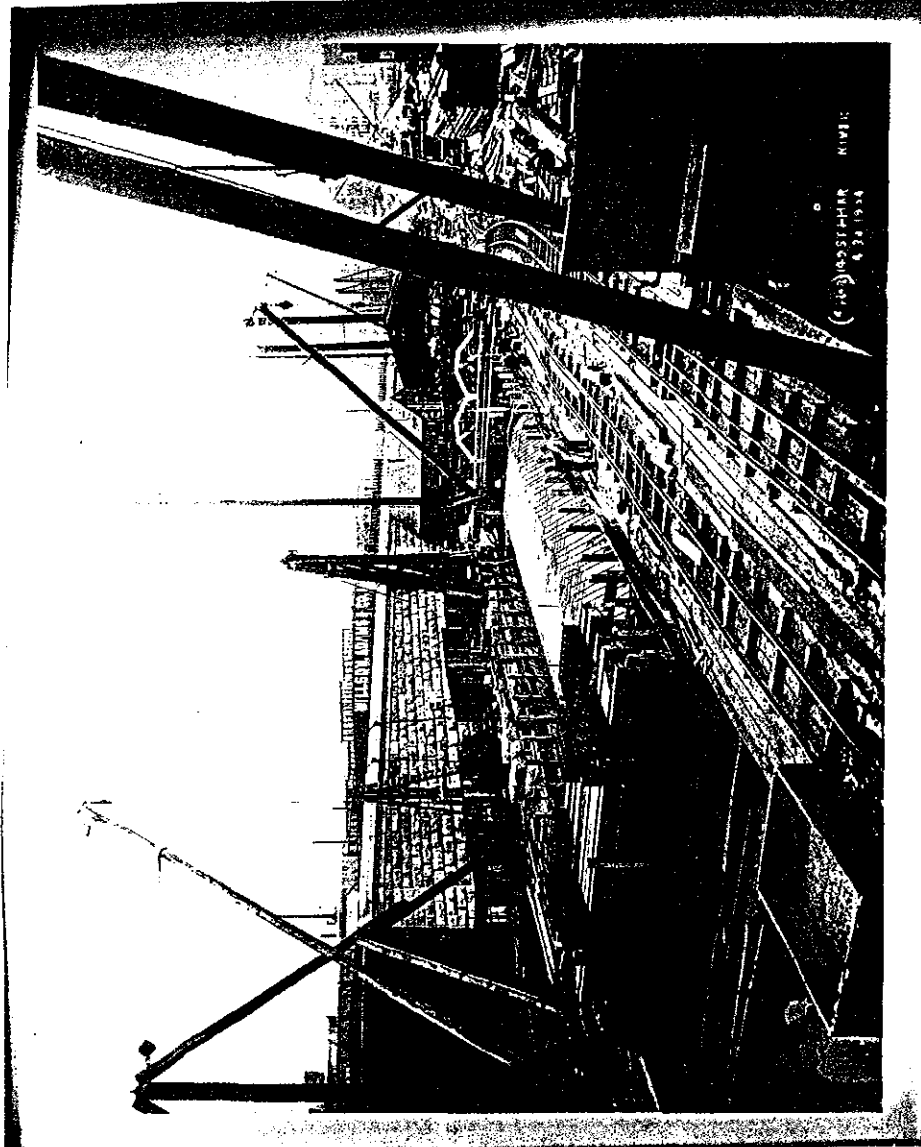
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
EXCAVATION AND STEELWORK FOR STATION AT BROADWAY AND
157TH STREET. NOTE SPLAY OF STATION PLATFORM WALL
AT LEFT CENTER AND RELATION OF STATION TO STREET SUR-
FACE. APRIL 26, 1904.



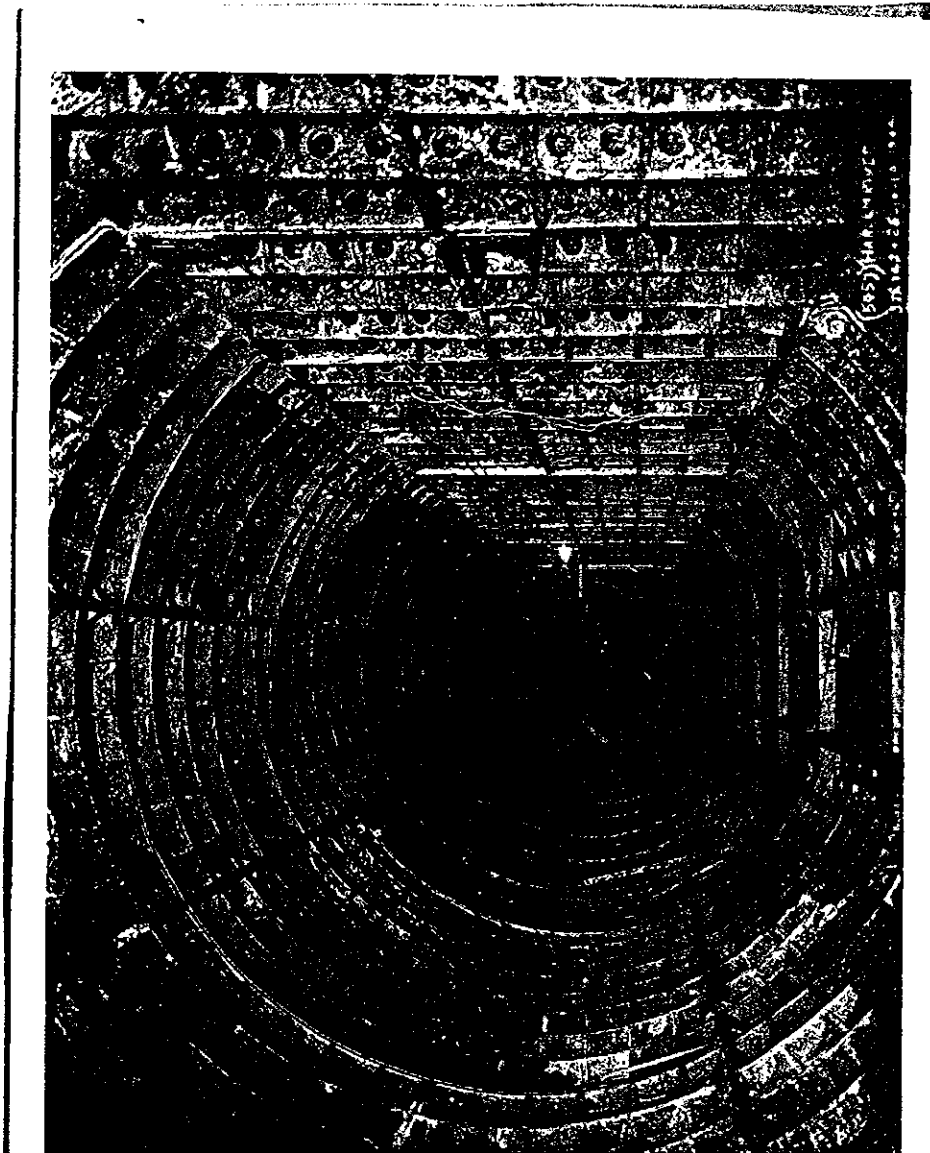
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
COMPLETED STEELWORK AND TRACKS AT ELM AND PRINCE
STREETS. APRIL 28, 1904.



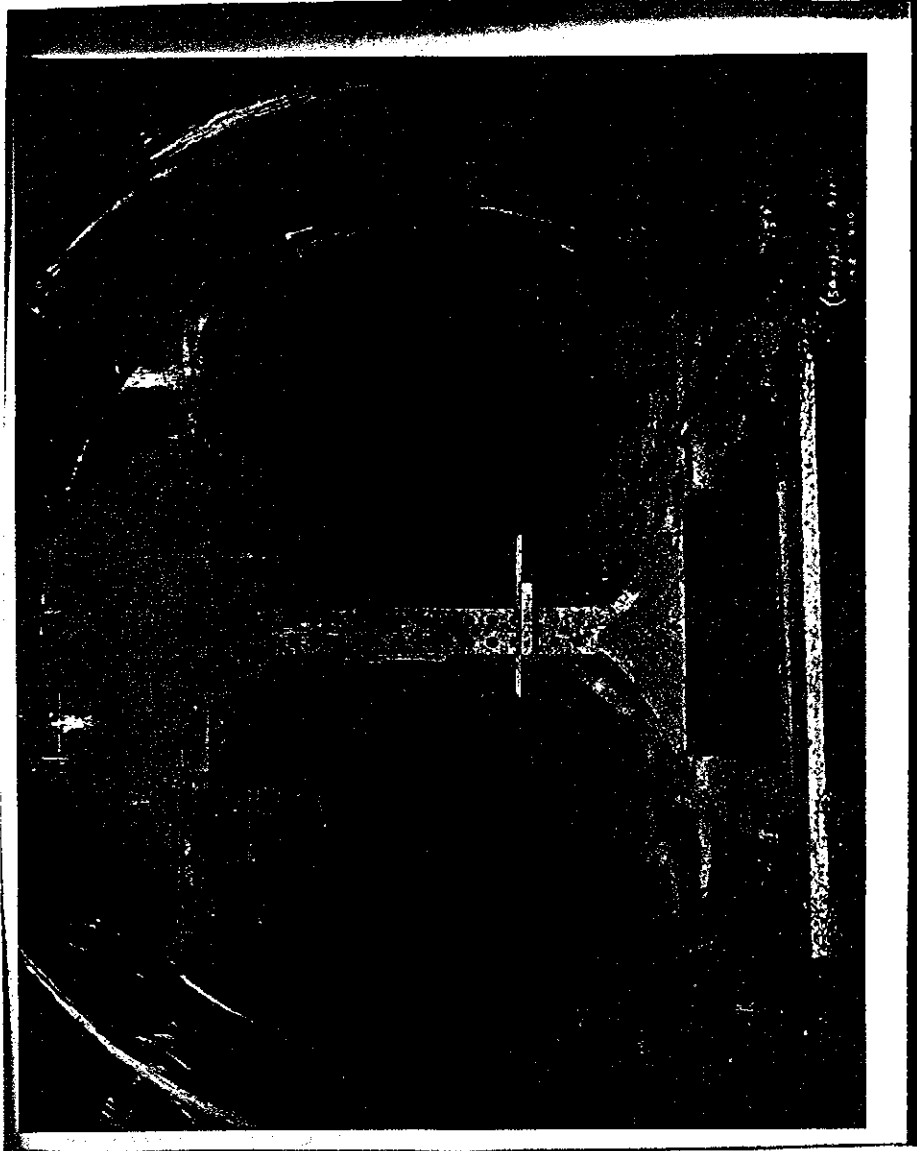
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
CONSTRUCTION AT HARLEM RIVER.



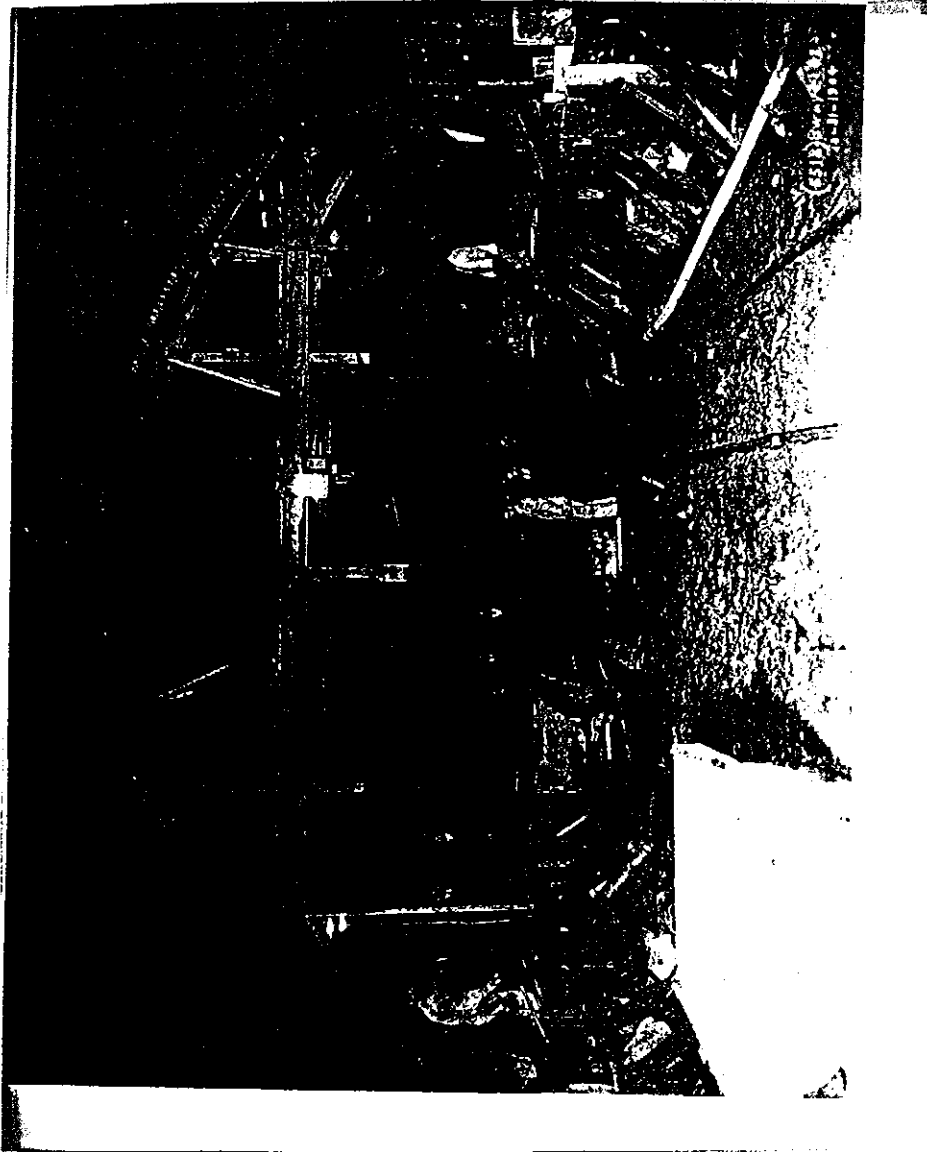
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
INTERIOR OF ONE OF TWO CAST IRON TUBES BENEATH HARLEM
RIVER. OCTOBER 10, 1904.



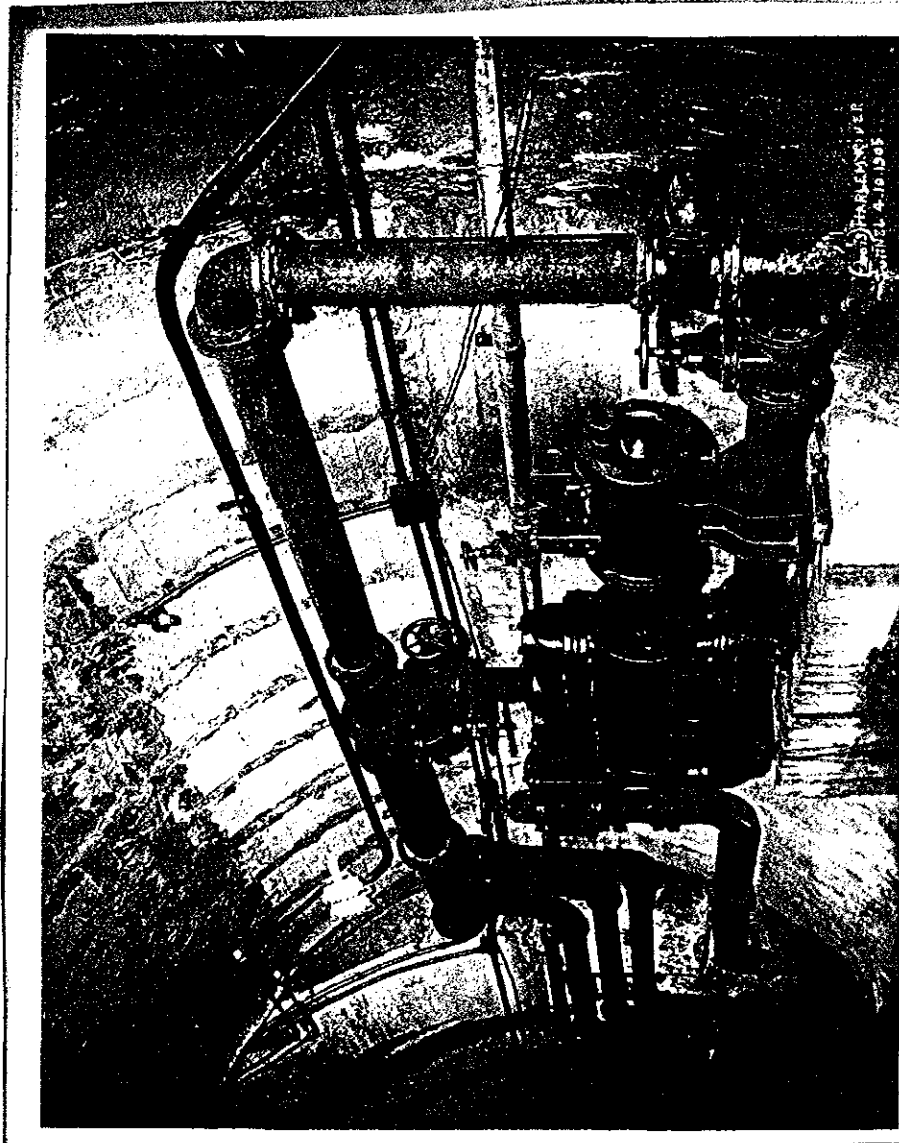
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
SECTION OF TWIN CAST IRON TUBES BENEATH
HARLEM RIVER. NOTE LONGITUDINAL HOLES IN
CENTER DIAPHRAM FOR CARRYING ELECTRICAL
CABLES. October 10, 1904.



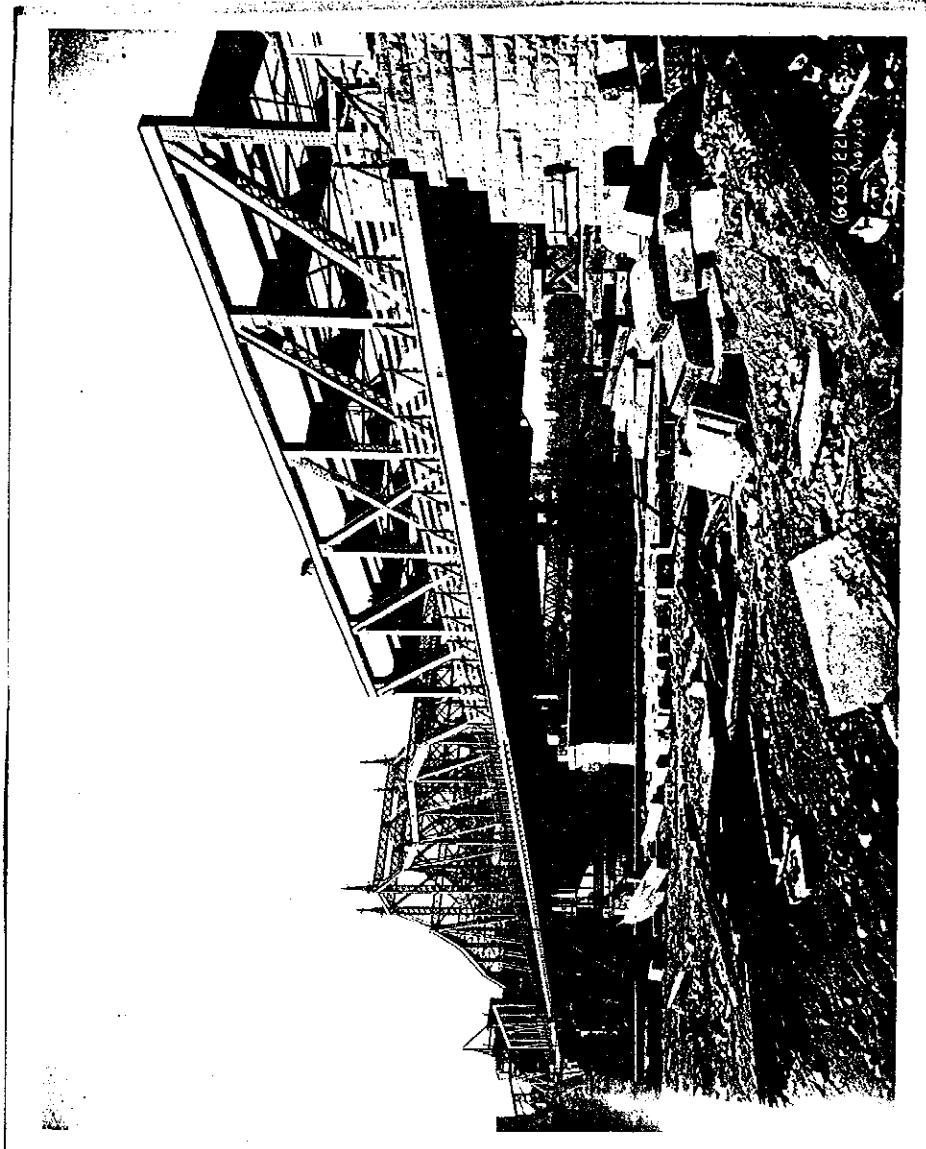
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
TUNNEL AND FALSEWORK FOR CARRYING BRICK
ARCH CEILING AT BROADWAY AND 168TH STREET
STATION. October 31, 1904.



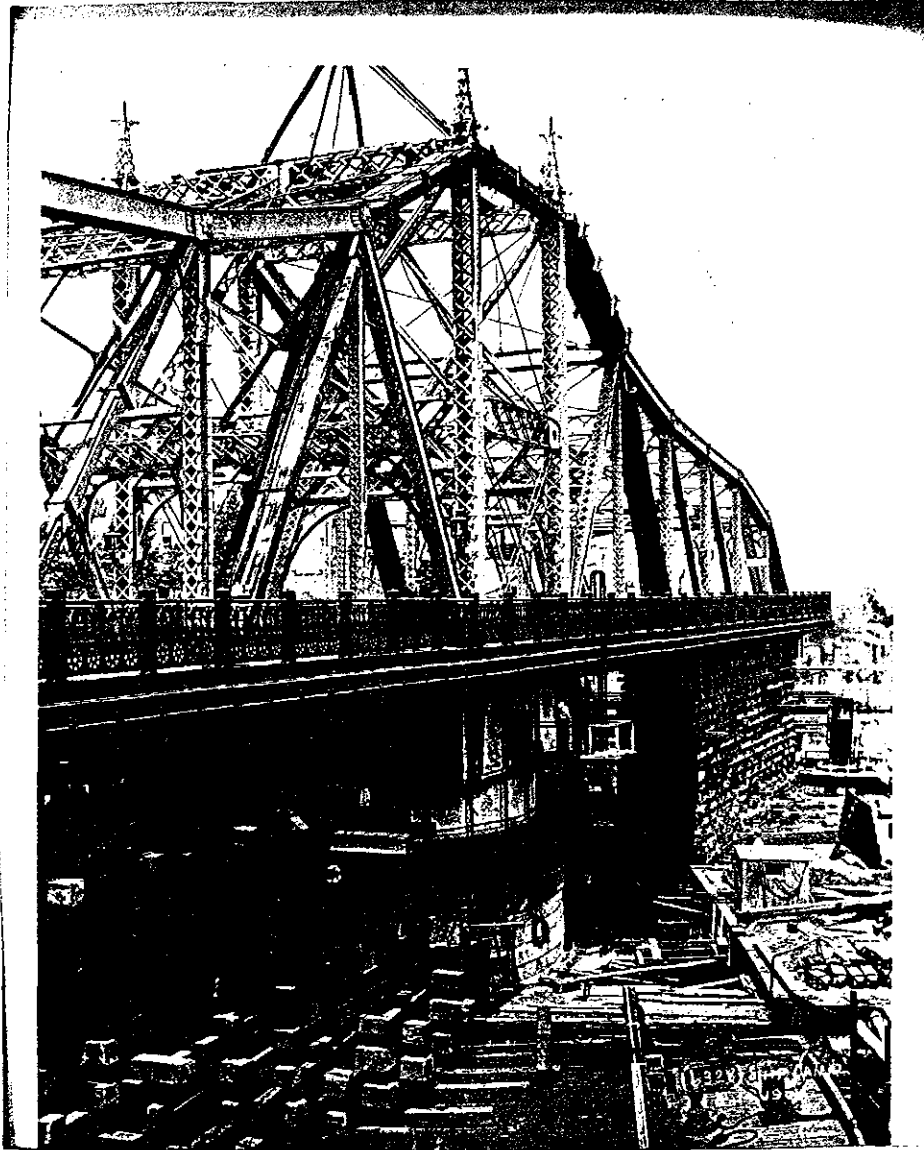
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

- 3 Photocopied August 1978. (B)
"CAMERON" WATER PUMP INSTALLED IN HARLEM
RIVER TUNNEL TO PREVENT FLOODING OF TRACKS.
April 19, 1905.



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Photocopied August 1978. (B)
BRIDGE CONSTRUCTION OVER HARLEM SHIP
CANAL AT 221ST STREET AND BROADWAY. SUBWAY
TO OCCUPY UPPER DECK OF STRUCTURE.
November 10, 1905.



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Photocopied August 1978. (B)
BLOCKING USED TO RAISE ORIGINAL HARLEM
SHIP CANAL BRIDGE OFF ITS PIVOT PRIOR
TO BRIDGE BEING REMOVED BY BARGES.
June 14, 1906.



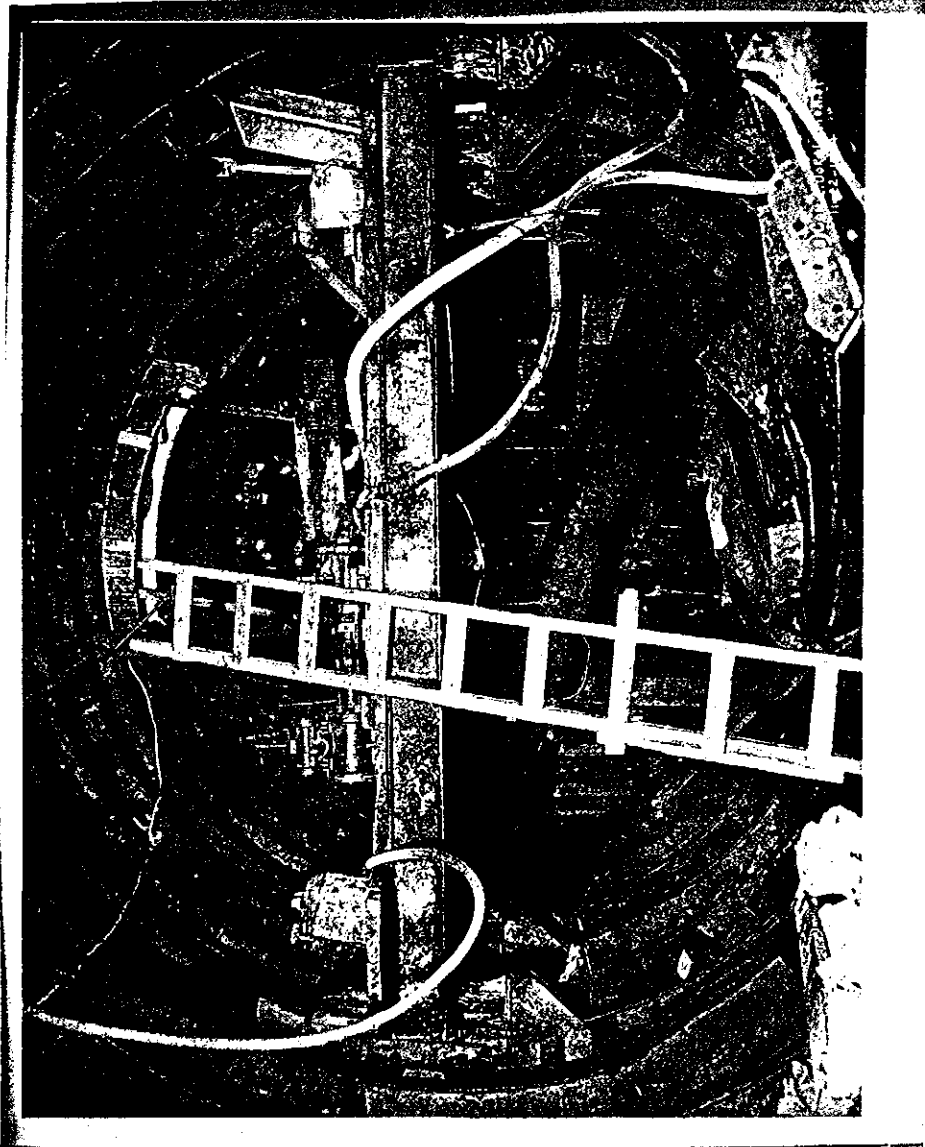
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
TUNNELLING ON CONTRACT 2 AT BATTERY PARK.
July 7, 1903.



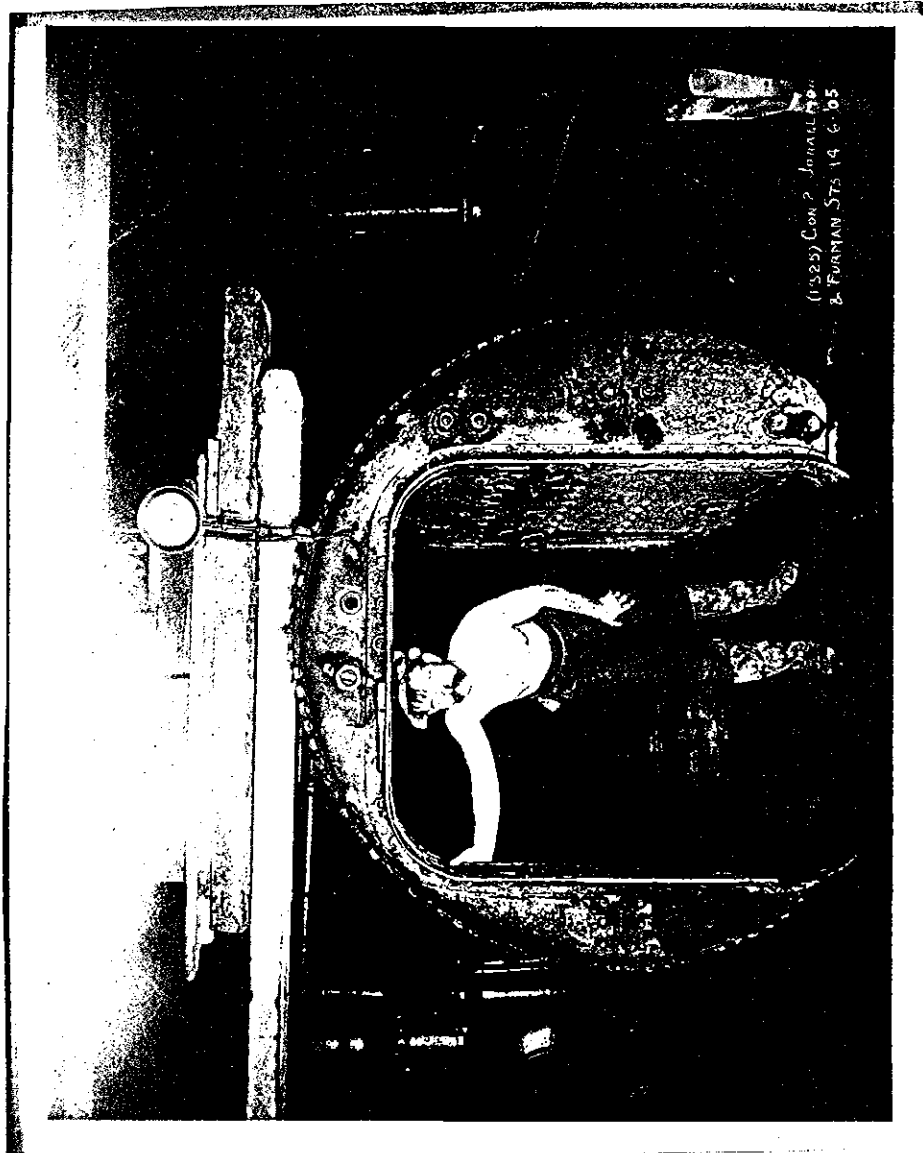
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
INSTALLATION OF CAST IRON PLATES FOR TUBE
FOR CONTRACT 2, JORALEMON STREET. December 6, 1903.



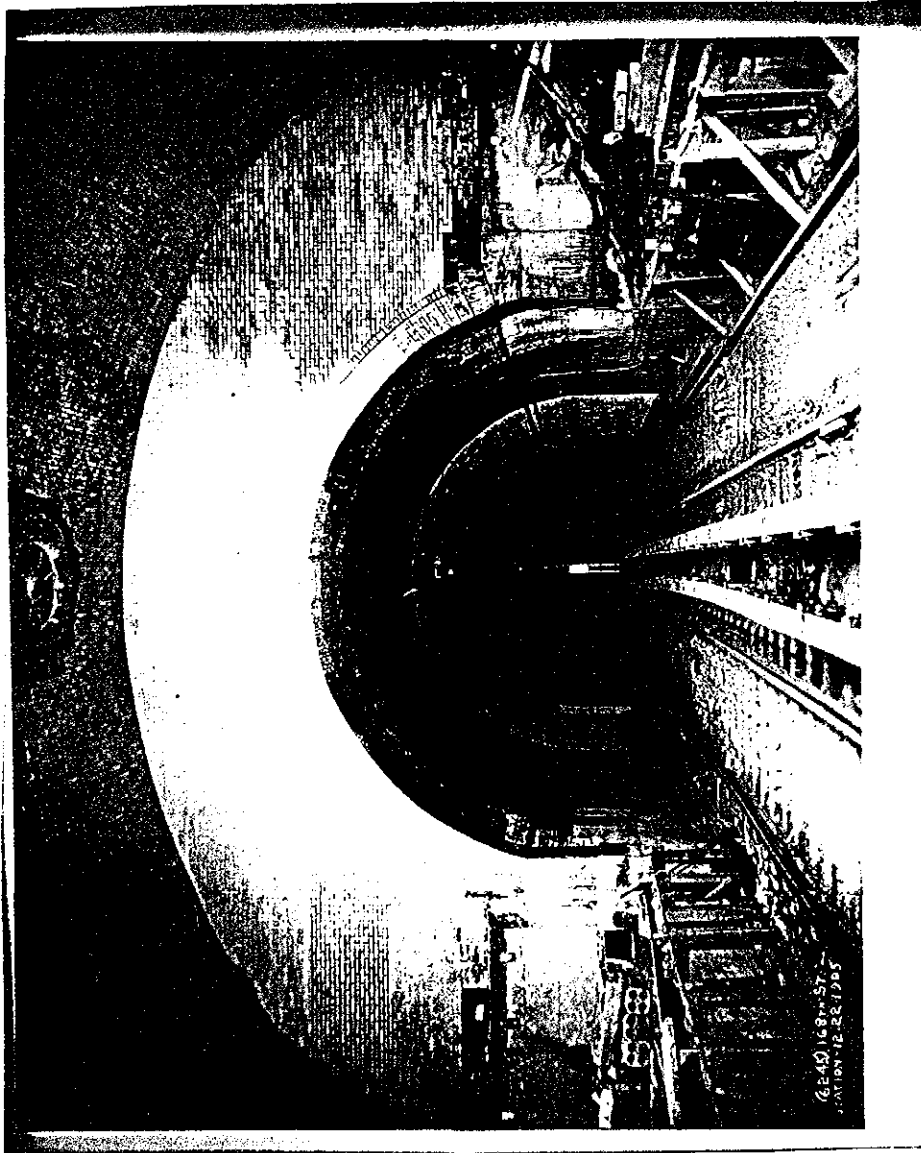
Photocopy of photograph. Copyright held by the New York Historical Society,
170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
INSTALLATION OF TUBE FOR CONTRACT 2, JORALEMON
STREET. November 22, 1904.



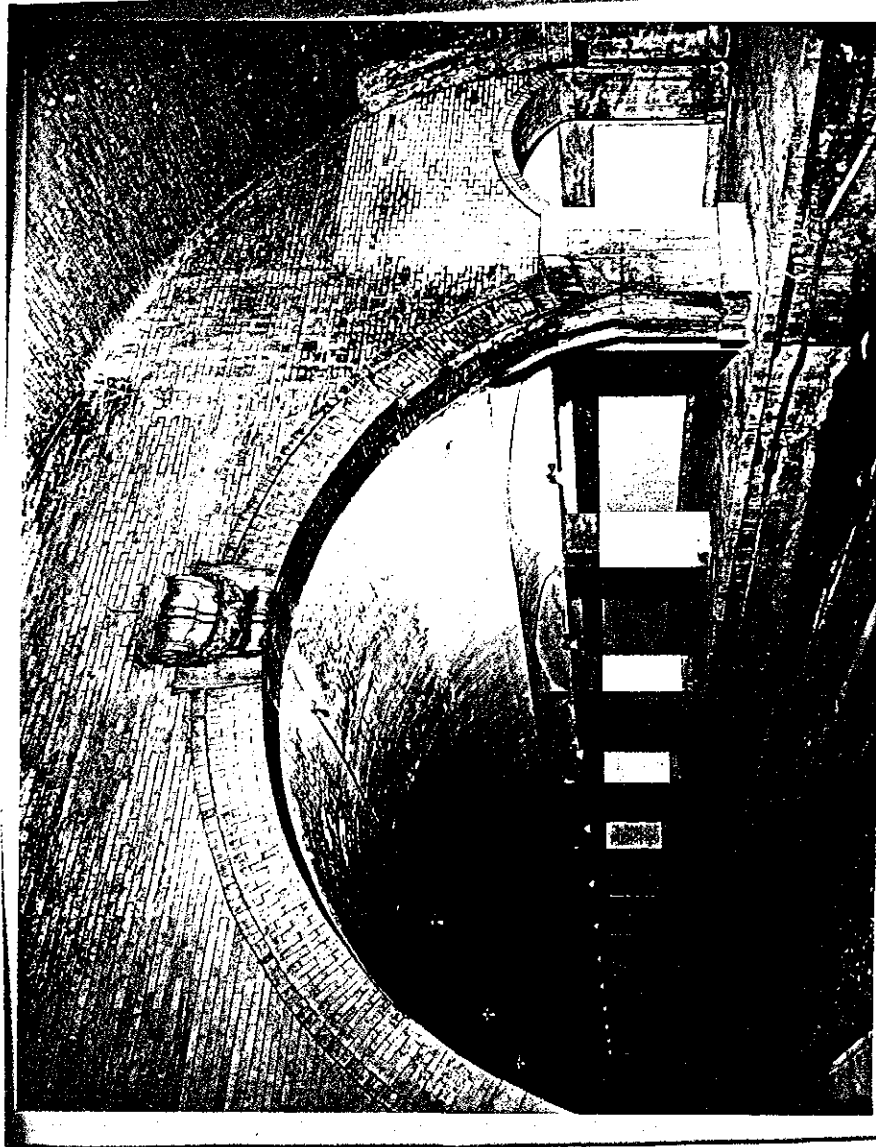
Photocopy of photograph. Copyright held by the New York Historical Society, 170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (8)
CONSTRUCTION ON CONTRACT 2,
JORALEMON AND FURMAN STREETS.
June 14, 1905.



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Photocopied August 1978. (B)
CONSTRUCTION OF END OF PLATFORM AT
168TH STREET STATION. (TRANSITION
FROM BRICK LINED ARCH AT STATION TO
CONCRETE ARCH TUNNEL.)
December 22, 1905.



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170 Central Park West, New York, N. Y., 10024.

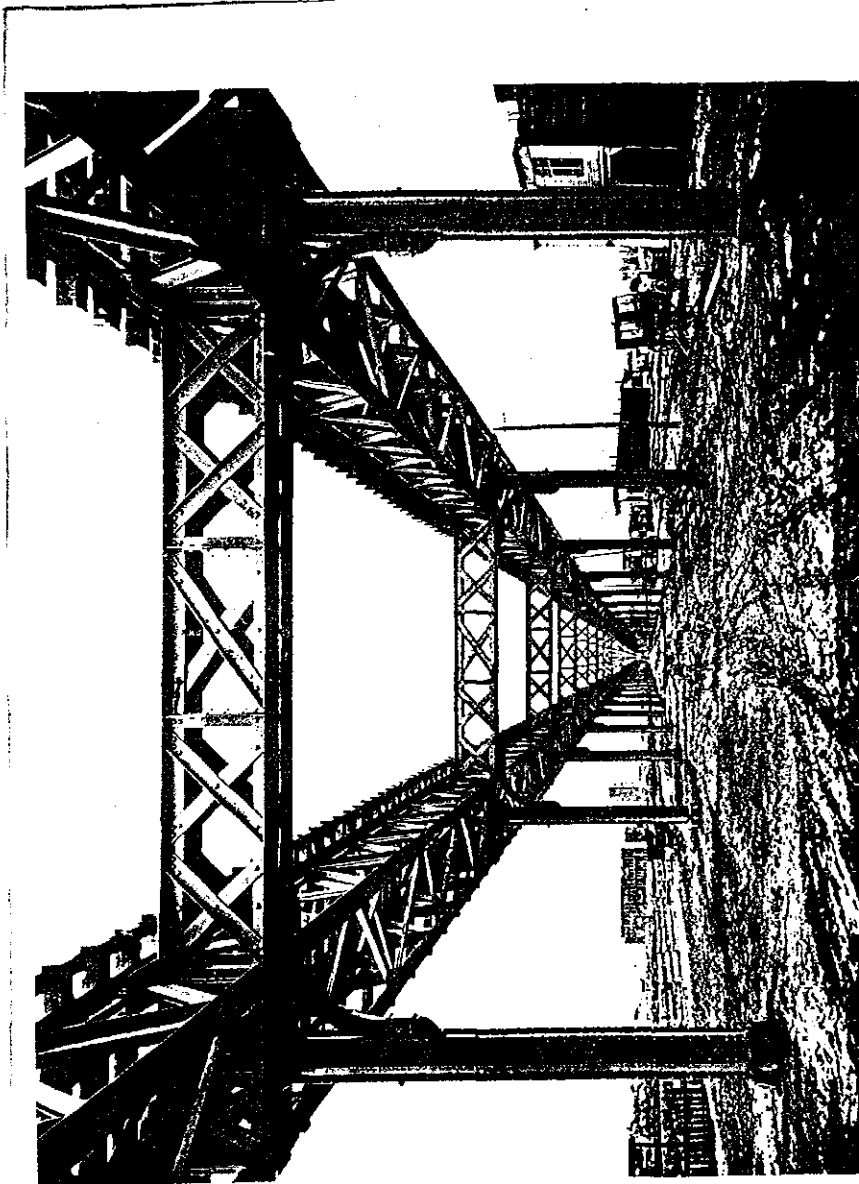
16

Photocopied August 1978. (B)
ARCH AT 181ST STREET STATION AND
EXTENSION OF PLATFORM.
June 21, 1911.



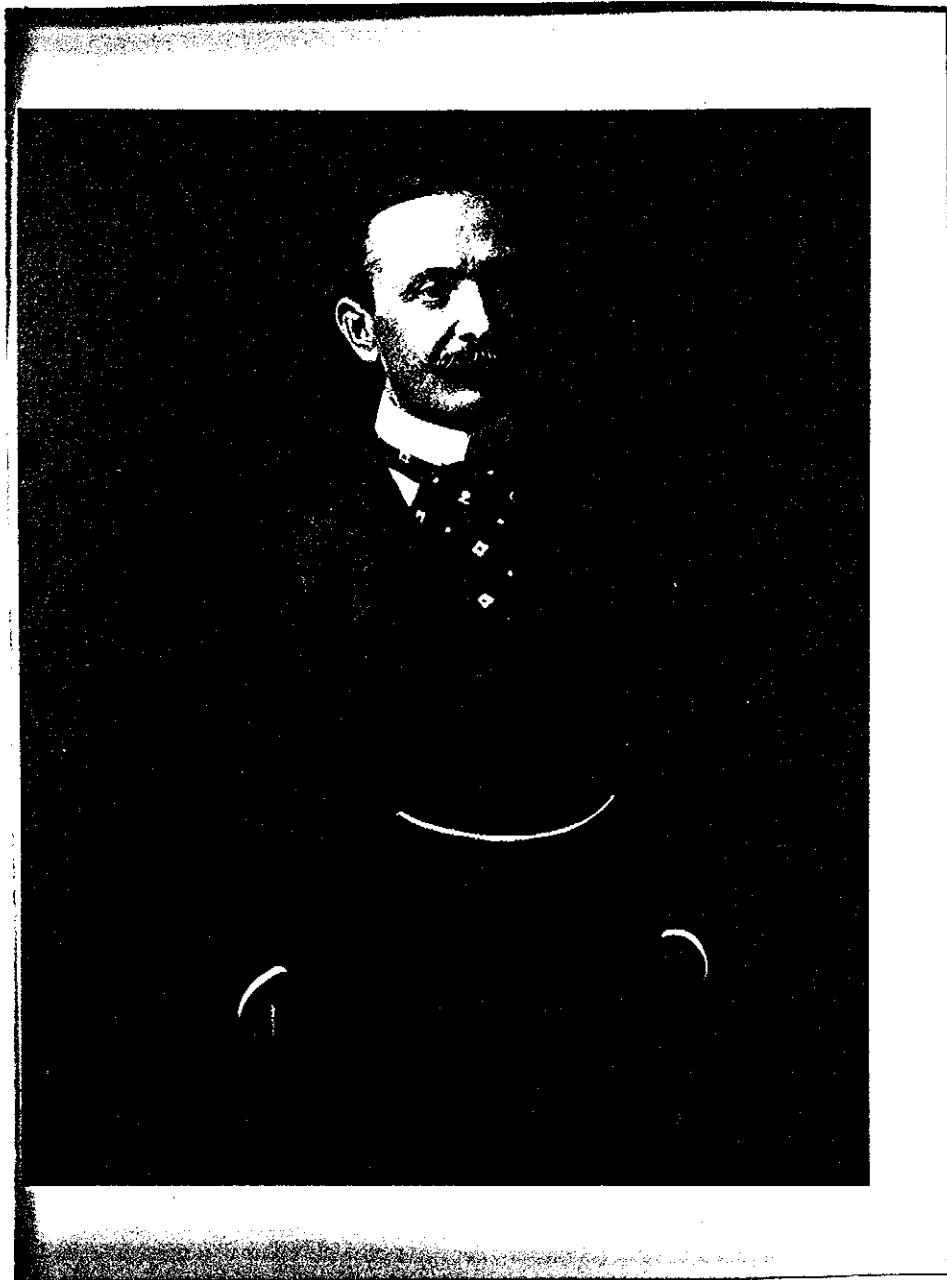
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170 Central Park West, New York, N. Y., 10024.

Photocopied August 1978. (B)
CONCRETE LINING APPLIED TO INTERIOR OF
CONTRACT 2, EAST RIVER TUNNEL.
May 25, 1905.



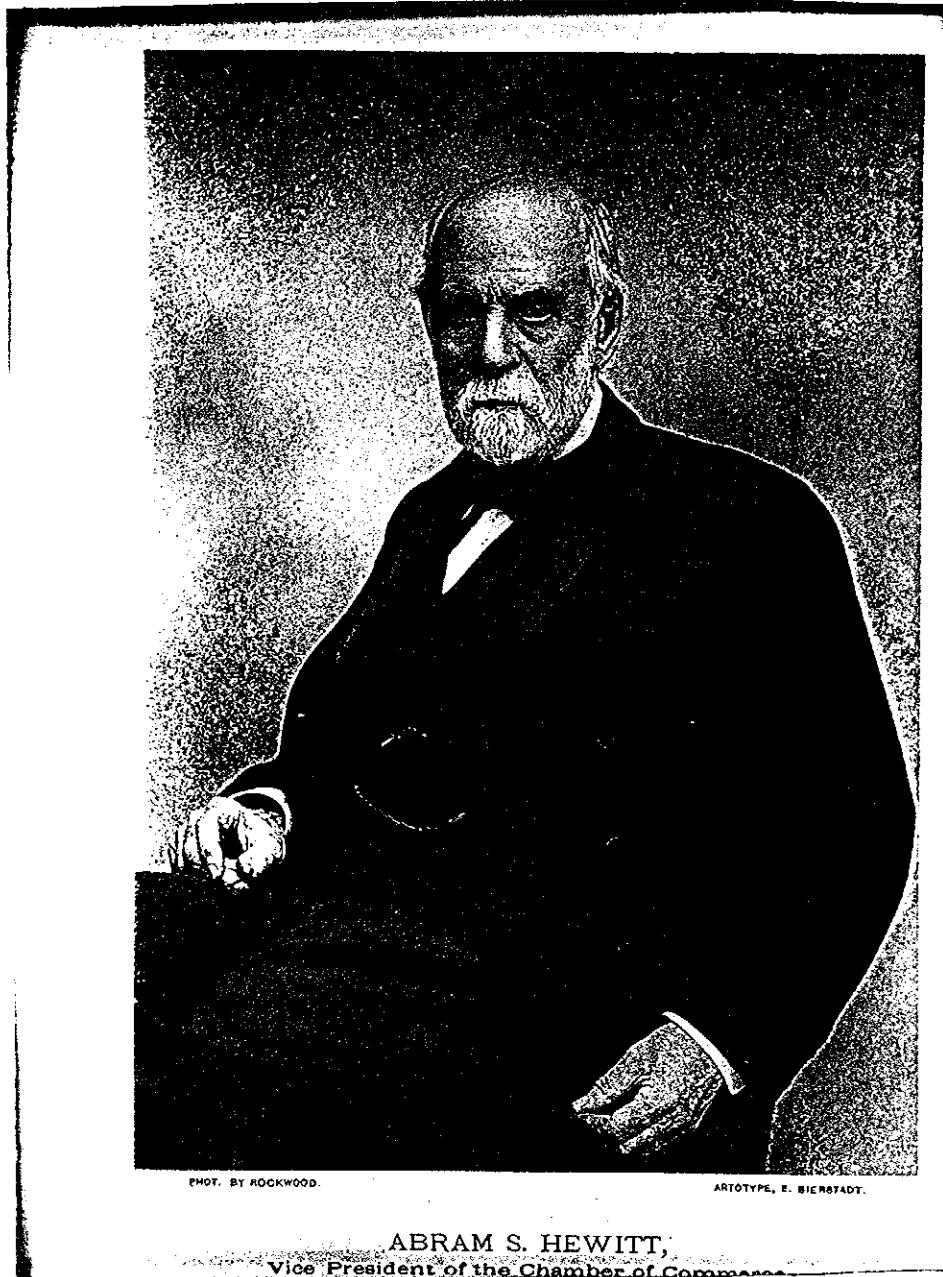
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
9TH AVENUE IN EARLY 1880'S, WHEN "ELS"
WERE GOING UP, ILLUSTRATING THE UNDEVELOPED
STATE OF UPPER WEST SIDE OF MANHATTAN.



Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
AUGUST BELMONT II.



Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
PHOTO BY ROCKWOOD OF ABRAM S. HEWITT.

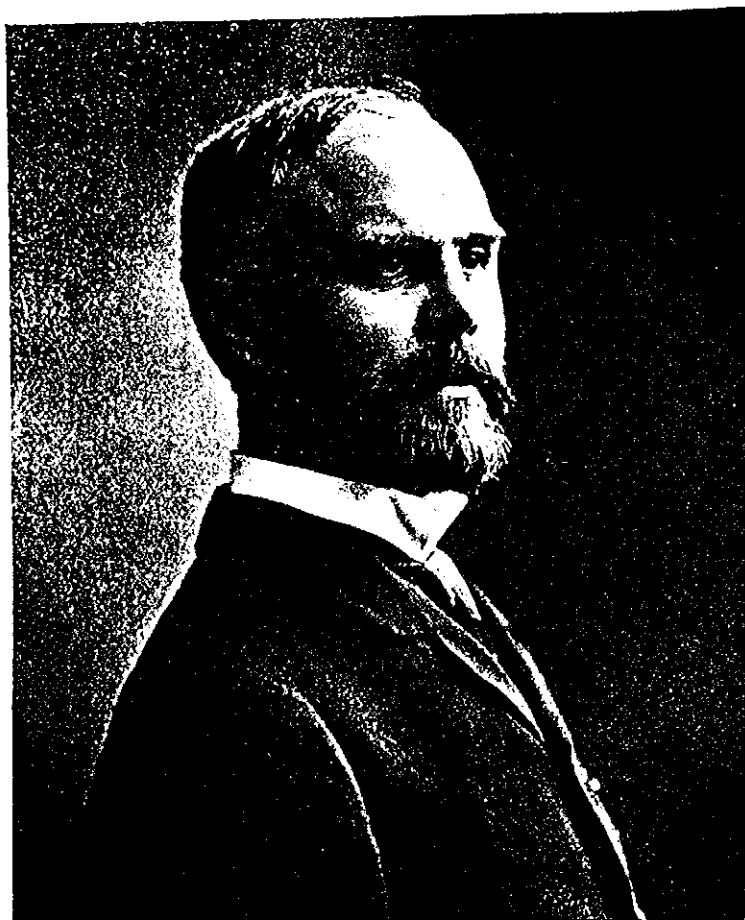


Photo by Davis & Sanford, N. Y.

WM. BARCLAY PARSONS.

FORMER CHIEF ENGINEER RAPID TRANSIT COMMISSION.

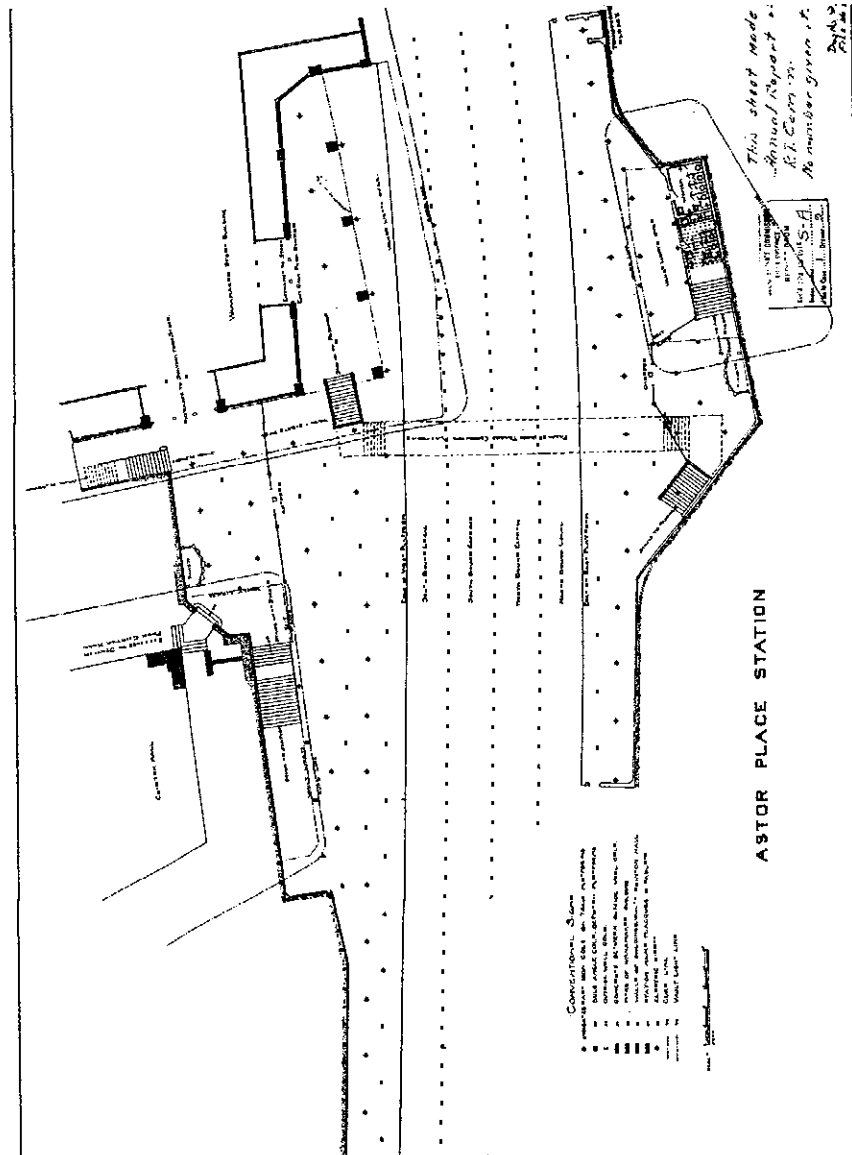
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
PHOTO BY DAVIS & SANDFORD (N.Y.) OF
WILLIAM BARCLAY PARSONS.



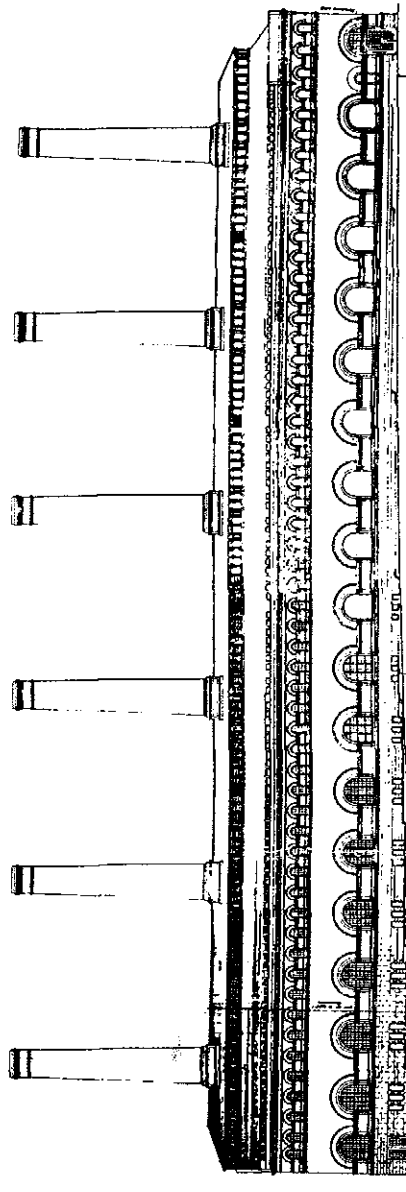
Photocopy of photograph from the collection of Hugh A. Dunne, Box 602,
Church Street Station, New York, N. Y., 10008.

Photocopied August 1978. (A)
SIGNING OF CONTRACT 1, JANUARY 15, 1900,
OFFICE OF THE RTC.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF PLAN, ASTOR PLACE STATION.

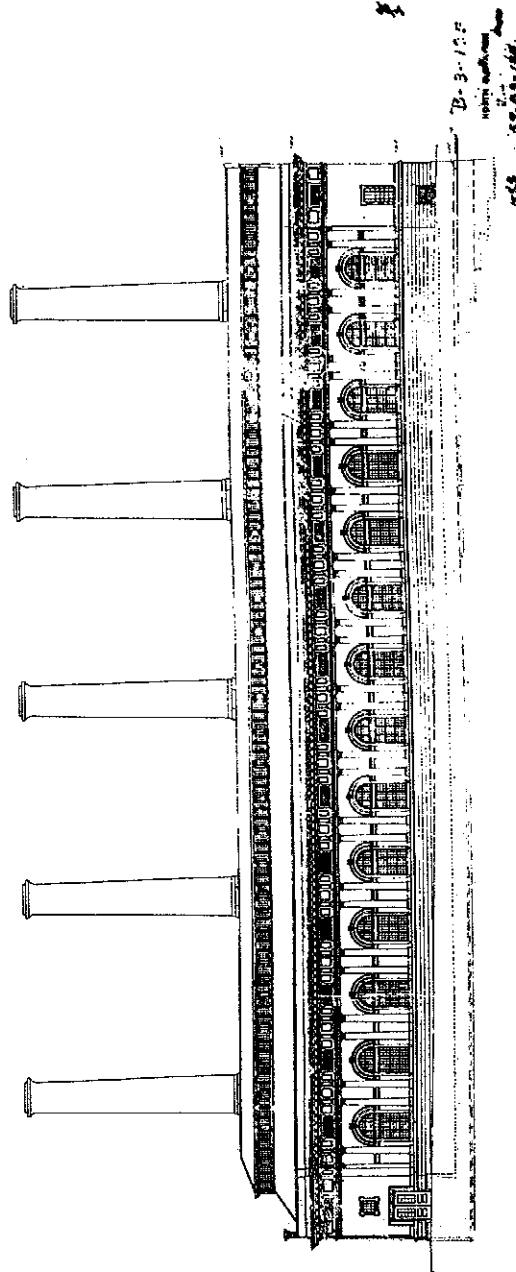


58-122-100

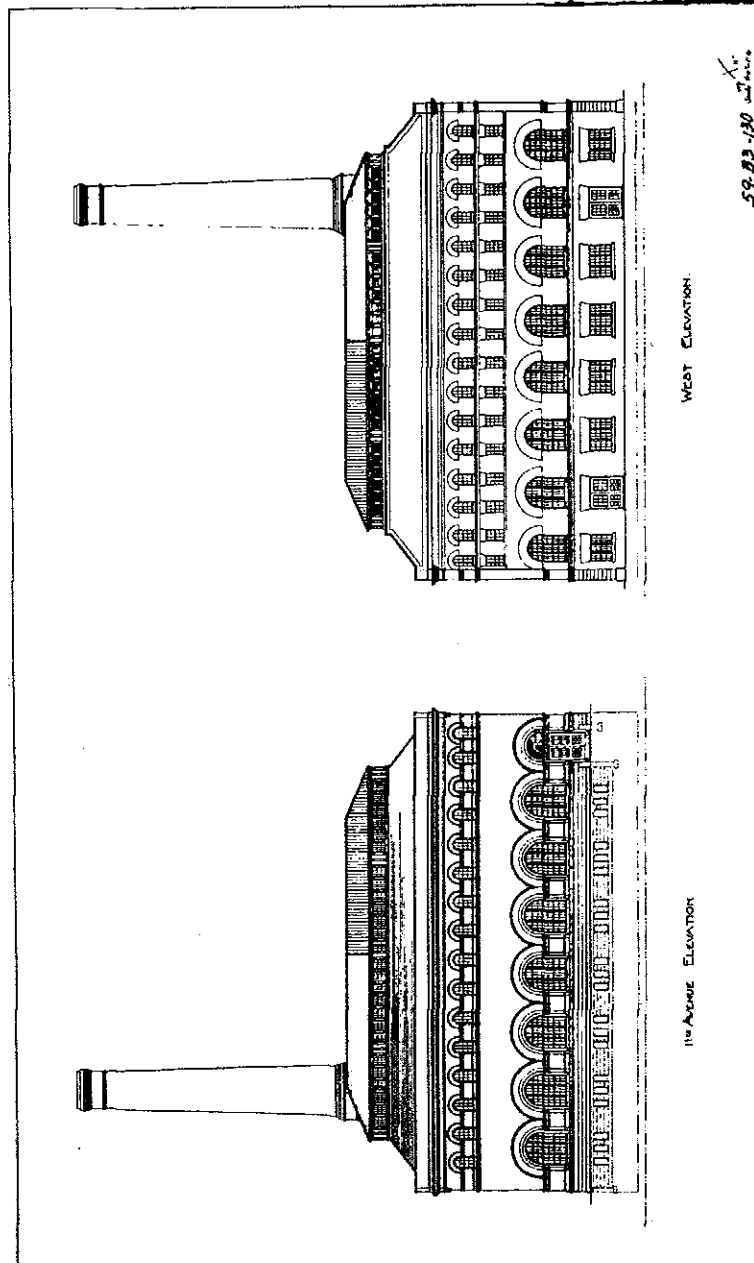
58-122-100

58th Street Elevation

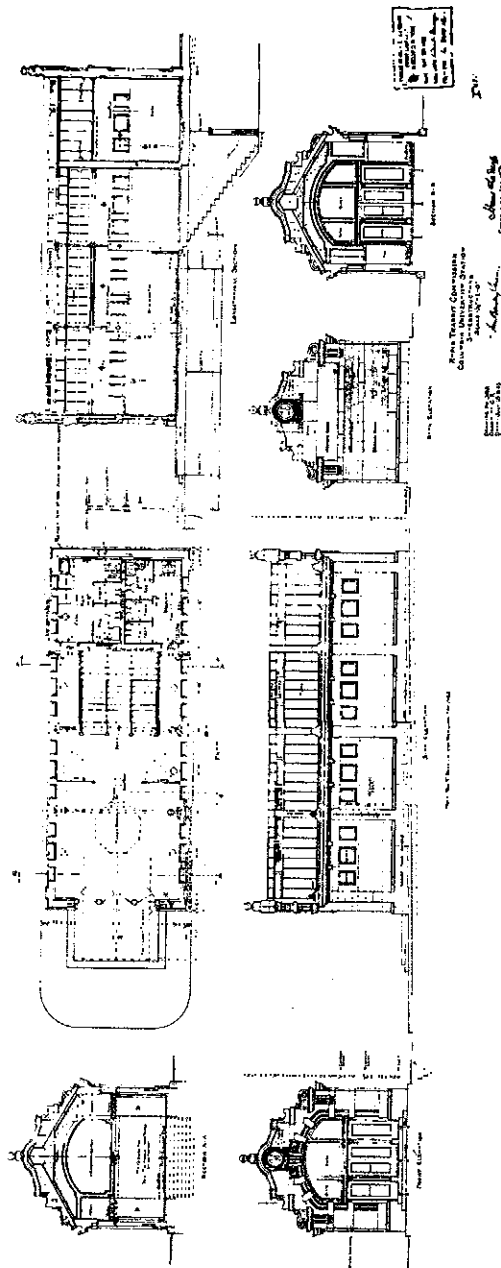
Photocopied August 1978.
DRAWING OF 58TH STREET ELEVATION OF
IRT POWERHOUSE. (COURTESY CONSOLIDATED EDISON)



Photocopied August 1978.
DRAWING OF NORTH ELEVATION OF
IRT POWERHOUSE. (COURTESY CONSOLIDATED EDISON)

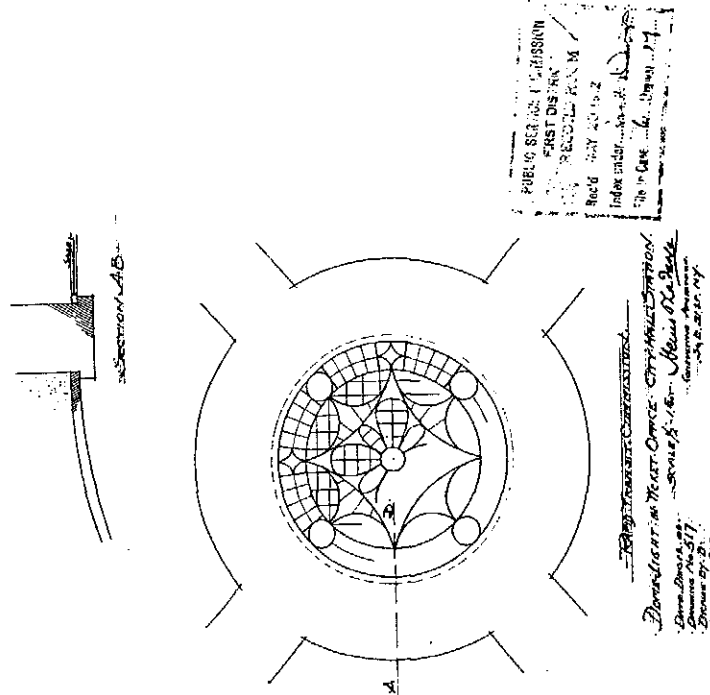


Photocopied August 1978.
DRAWING OF 11TH AVENUE ELEVATION AND WEST
ELEVATION OF IRT POWERHOUSE.
(COURTESY CONSOLIDATED EDISON)



Photocopied courtesy of the New York City Metropolitan Transit Authority.

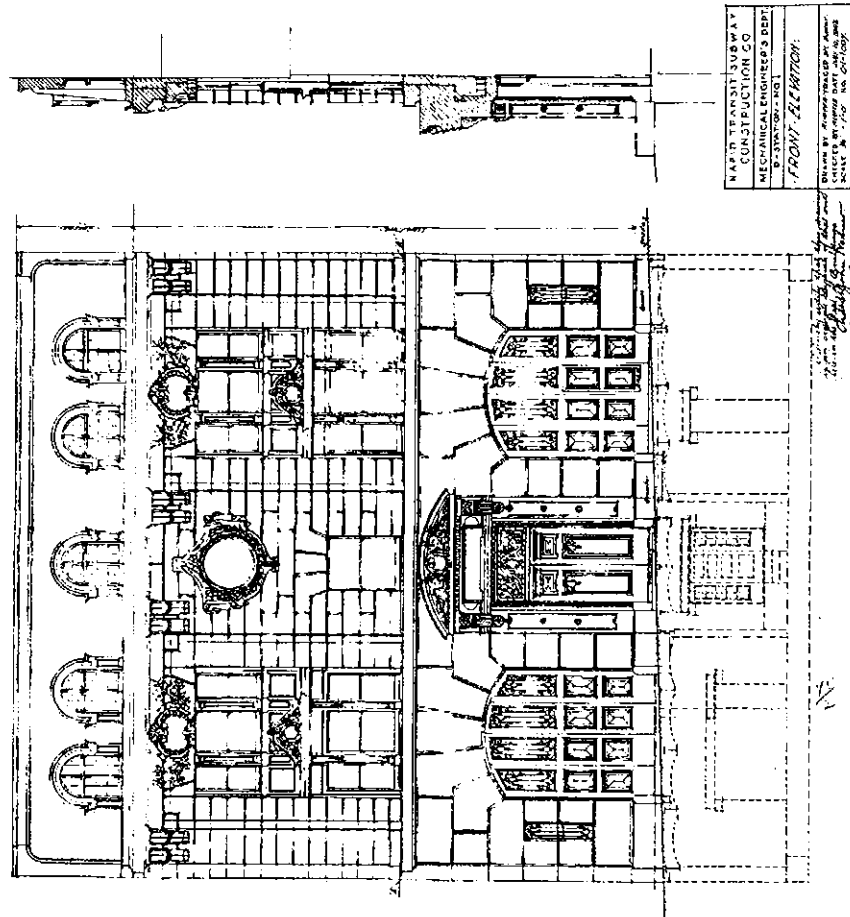
Photocopied August 1978. (MTA)
DRAWING OF ELEVATIONS, SECTIONS, AND PLANS
OF COLUMBIA UNIVERSITY STATION.



T 382

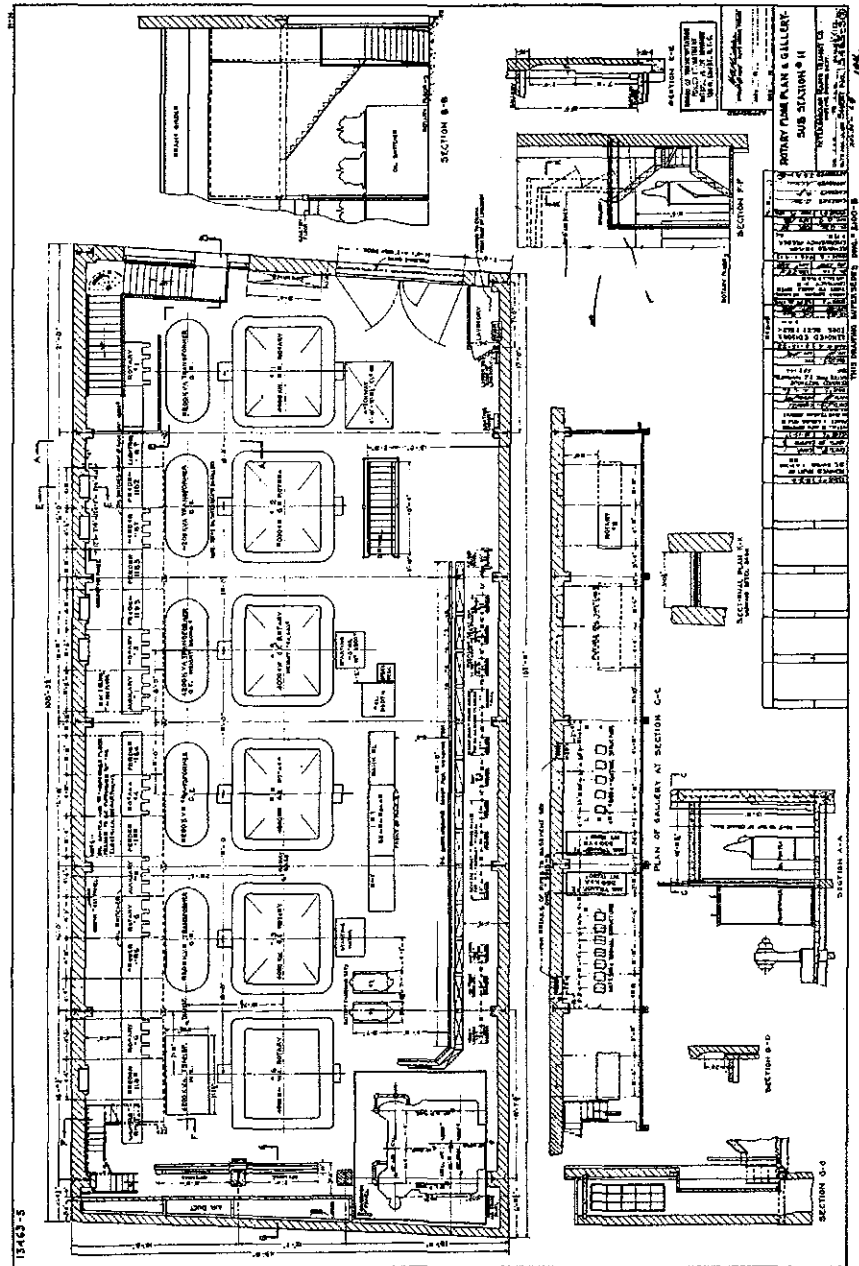
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DETAIL DRAWING, "DOME-LIGHT IN
TICKET OFFICE, CITY HALL STATION."



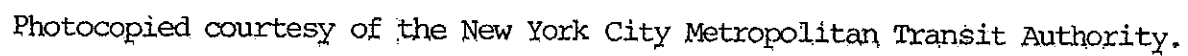
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
 DRAWING OF FRONT ELEVATION OF B-STATION
 (SUB-STATION).

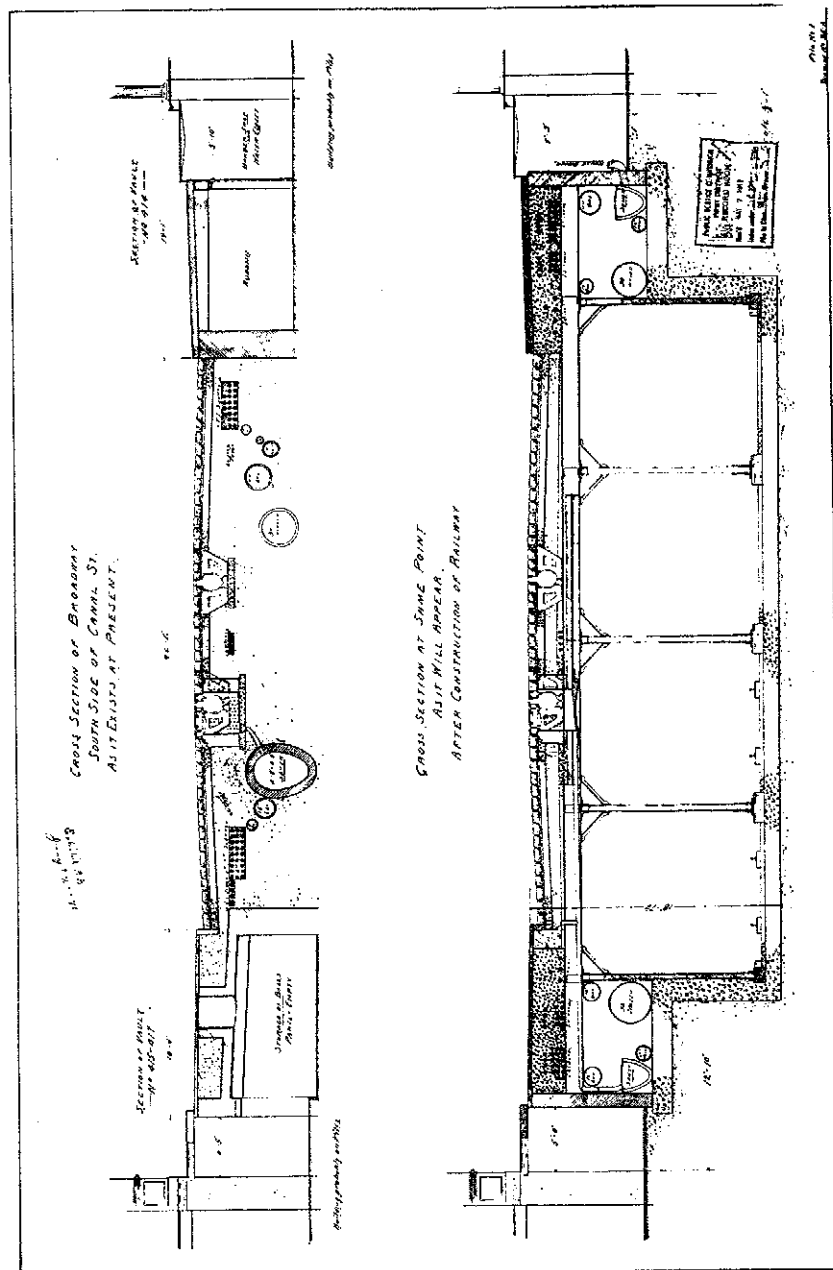


Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF ROTARY FLOOR PLAN AND GALLERY,
SUB-STATION # 11.

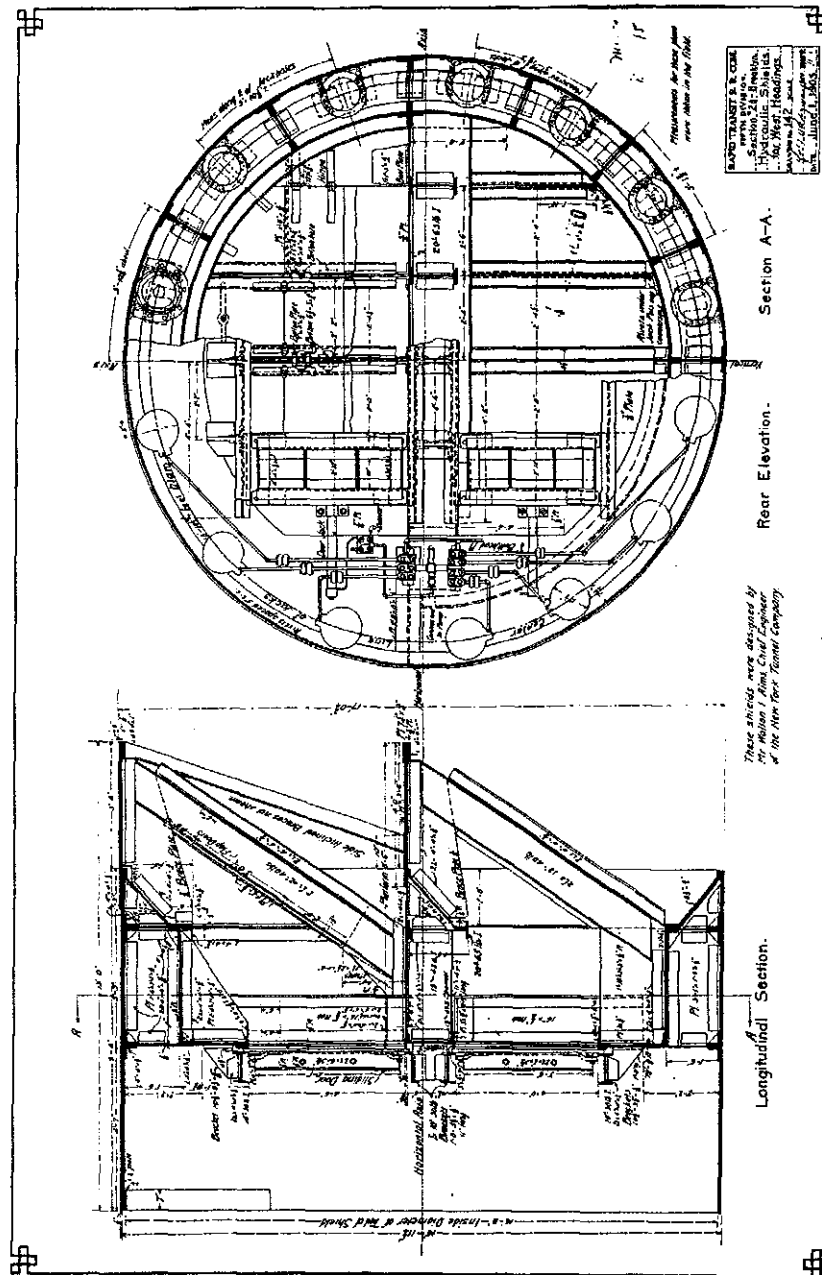


Photocopied August 1978. (MTA)
DRAWING OF DETAIL OF SIGNAL TOWERS.



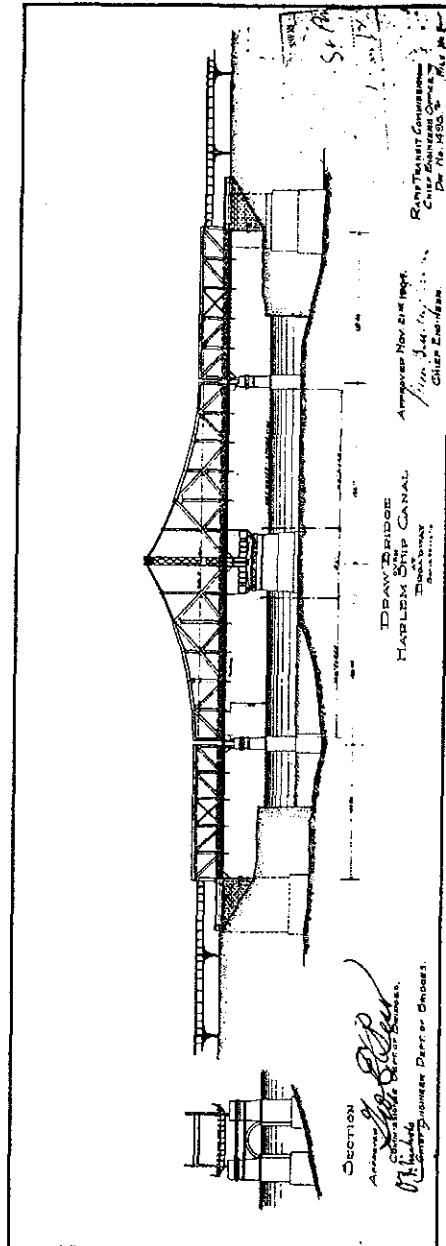
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF CROSS-SECTION OF BROADWAY
SOUTH SIDE OF CANAL STREET, SHOWING
BEFORE AND AFTER SUBWAY CONSTRUCTION.



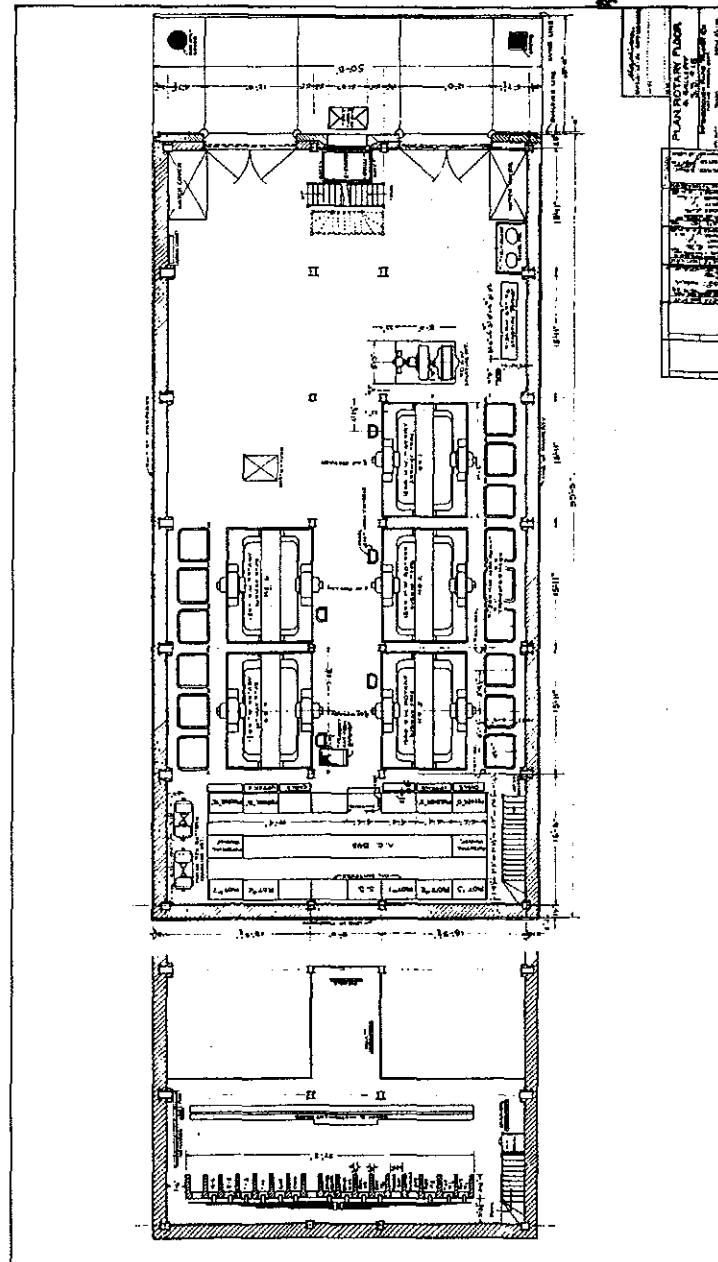
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF LONGITUDINAL SECTION AND REAR
ELEVATION OF HYDRAULIC SHIELDS.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

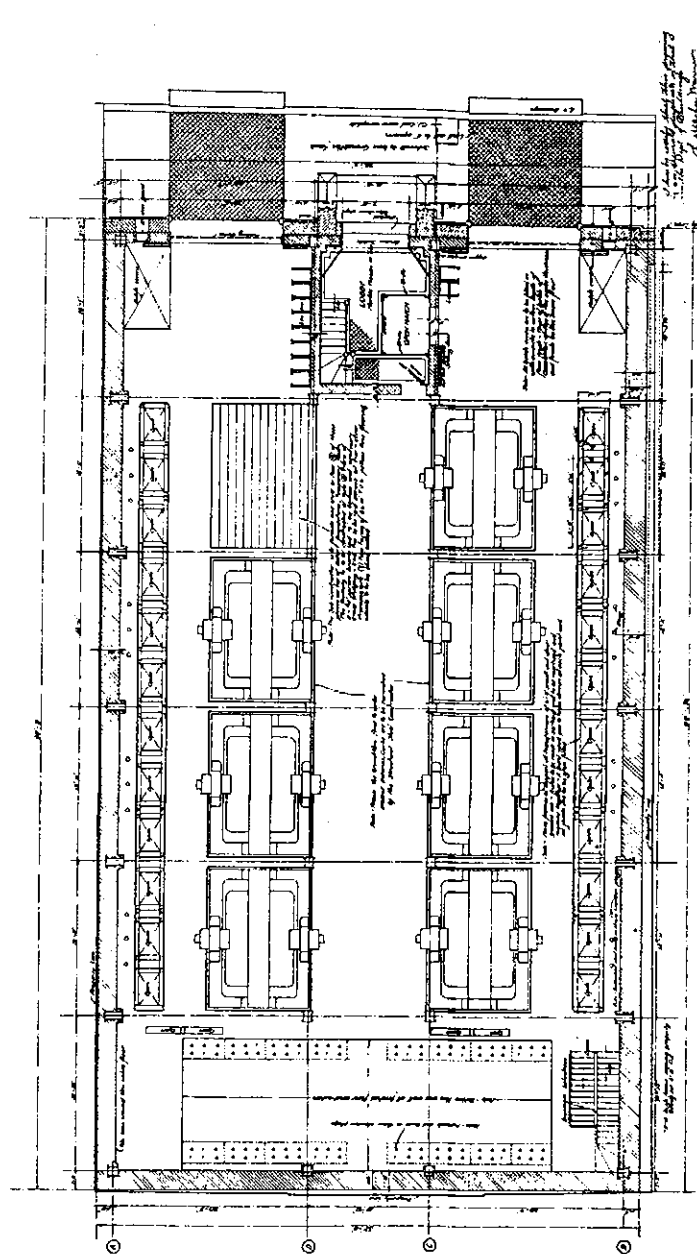
Photocopied August 1978. (MTA)
DRAWING OF DRAWBRIDGE OVER HARLEM SHIP
CANAL, SECTION AND ELEVATION.



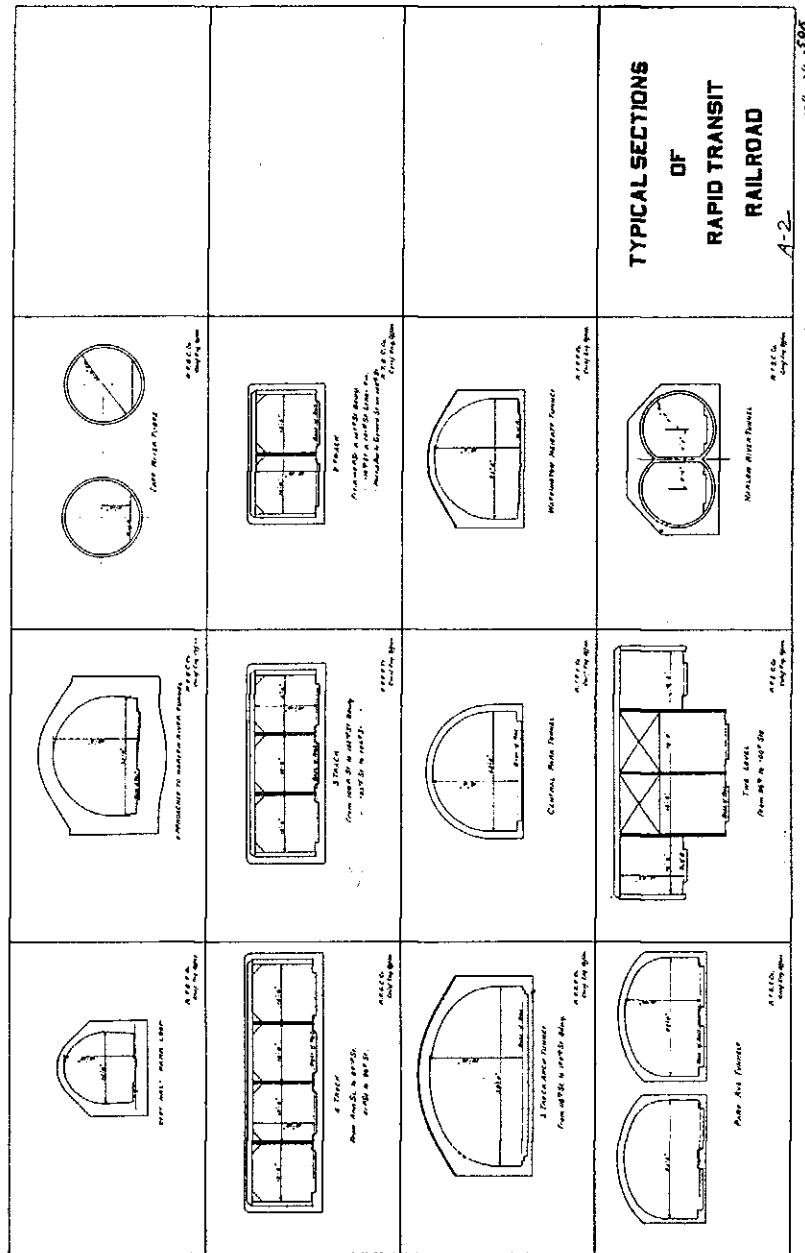
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF PLAN, ROTARY FLOOR AND GALLERY,
SUBSTATION #15.

RAPID TRANSIT SUBWAY CONSTRUCTION CO.	MECHANICAL ENGINEER'S DEPT. SUB-STATION - NO. 1	ROTARY FLOOR. ELEVATION + 12'-0"	BRASS SYMBOLS INSTALLED BY A.P.M. RECEIVED BY ORDER DATE JUL 26, 1966
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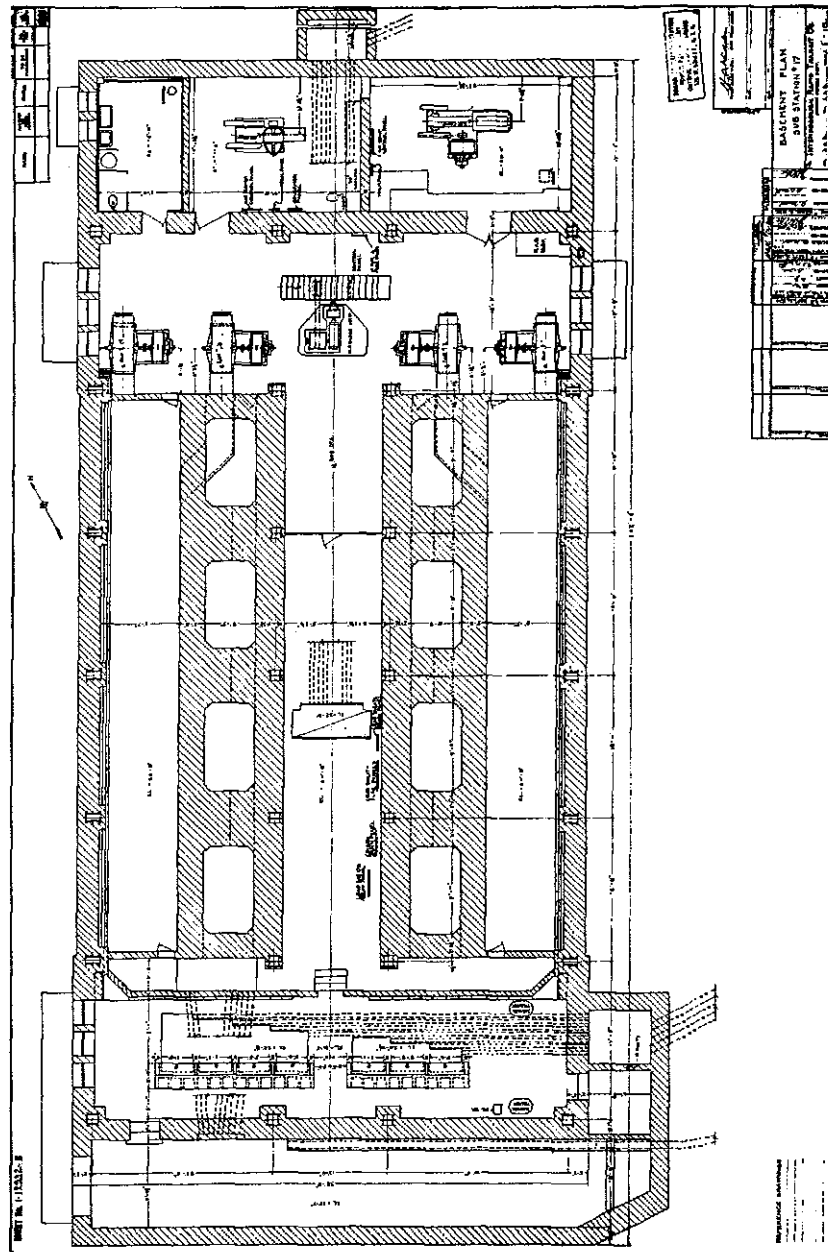


Photocopied August 1978. (MTA)
DRAWING OF PLAN OF ROTARY FLOOR, SUBSTATION #1.



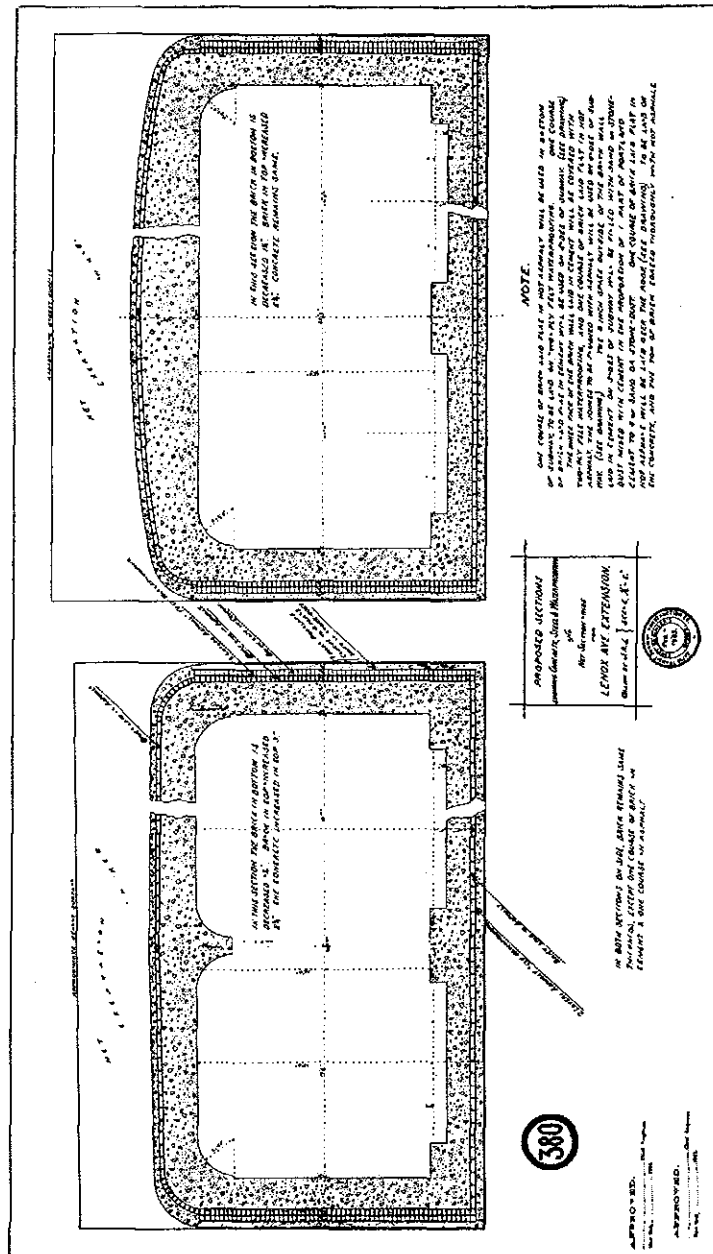
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF TYPICAL SECTIONS OF RAPID
TRANSIT RAILROAD.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

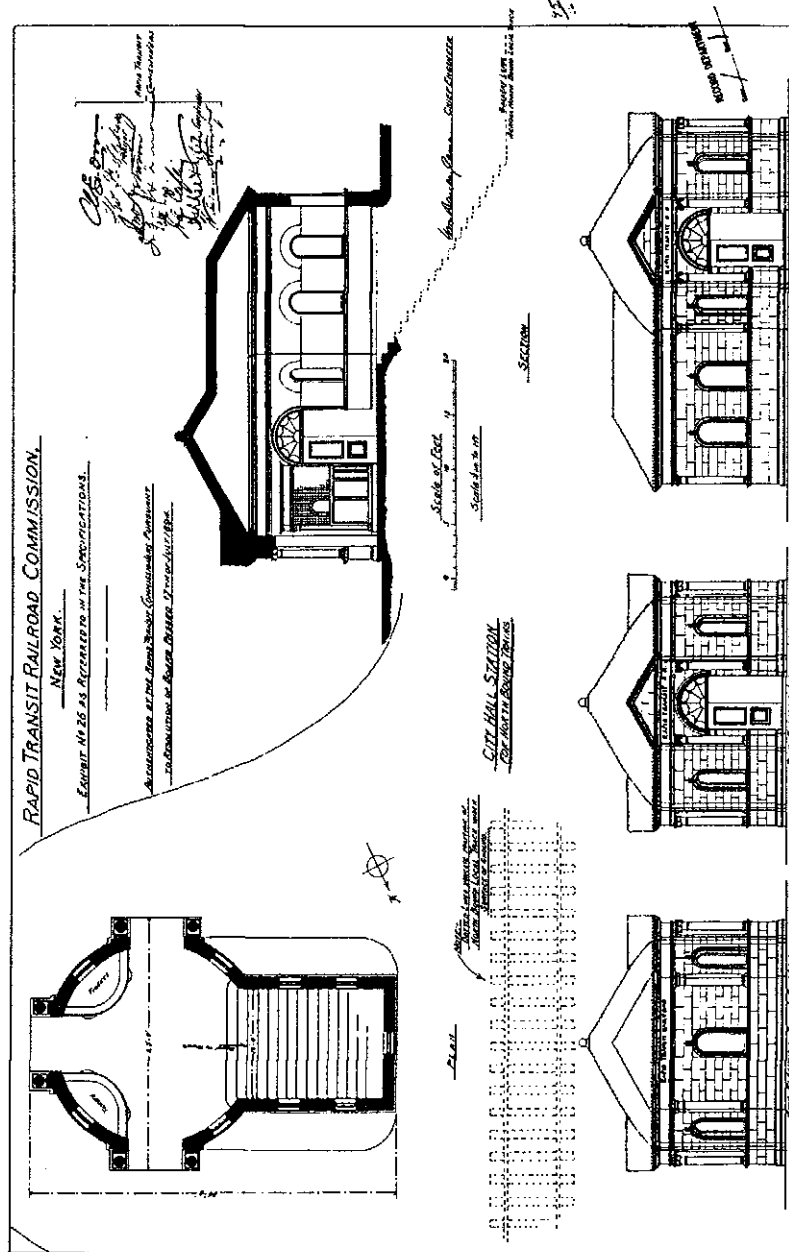
Photocopied August 1978. (MTA)
DRAWING OF BASEMENT PLAN, SUBSTATION #17.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

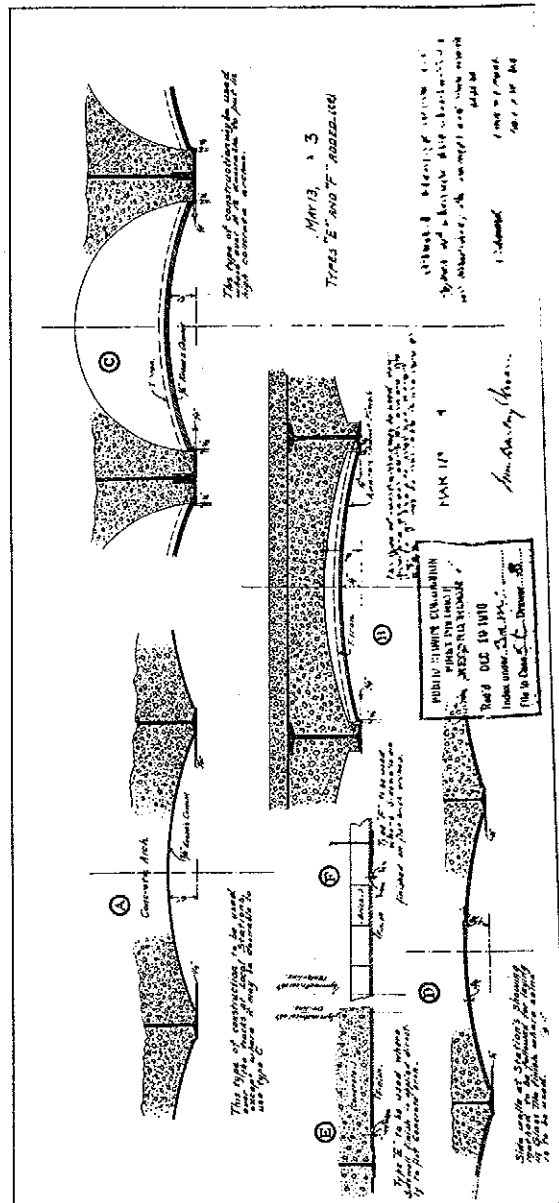
Photocopied August 1978. (MTA)
DRAWING OF PROPOSED SECTIONS SHOWING
CONCRETE, STEEL AND WATERPROOFING...FOR
LENOX AVENUE EXTENSION.

Photocopied August 1978. (MTA)
DRAWING OF LAYOUT OF DUCTS AND MANHOLES
FROM SUBSTATION #11.



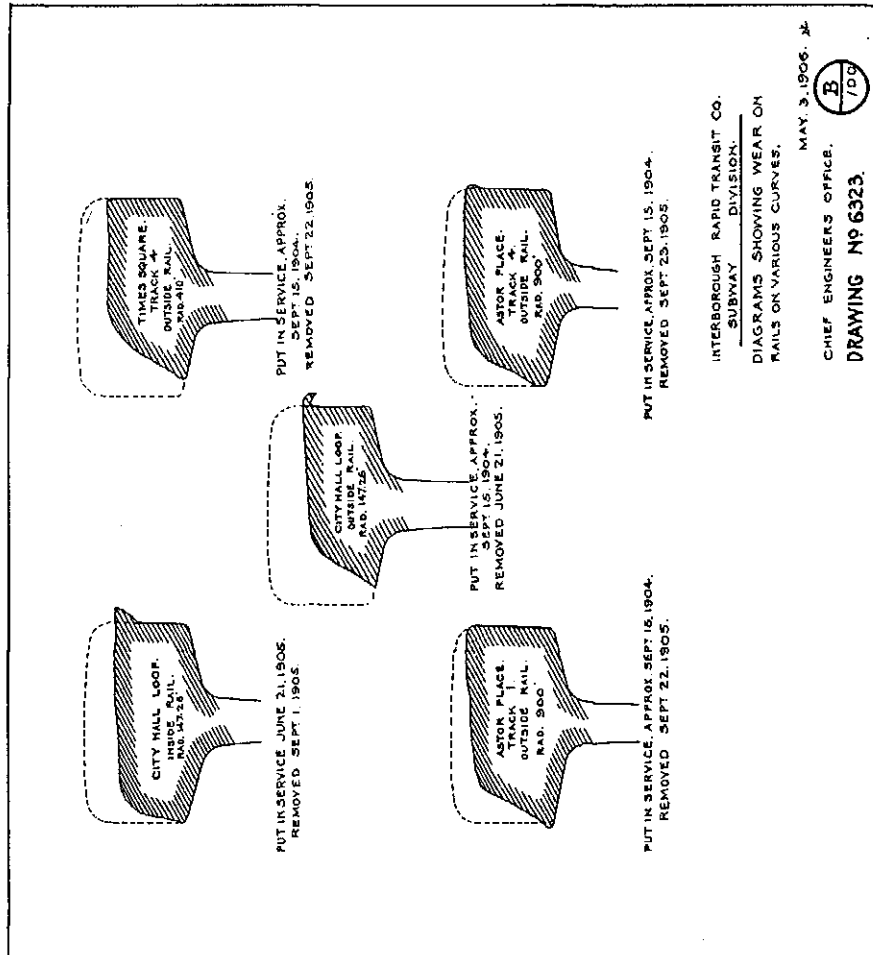
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING (PLAN, SECTION, ELEVATIONS)
OF CITY HALL STATION FOR NORTHBOUND TRAINS.



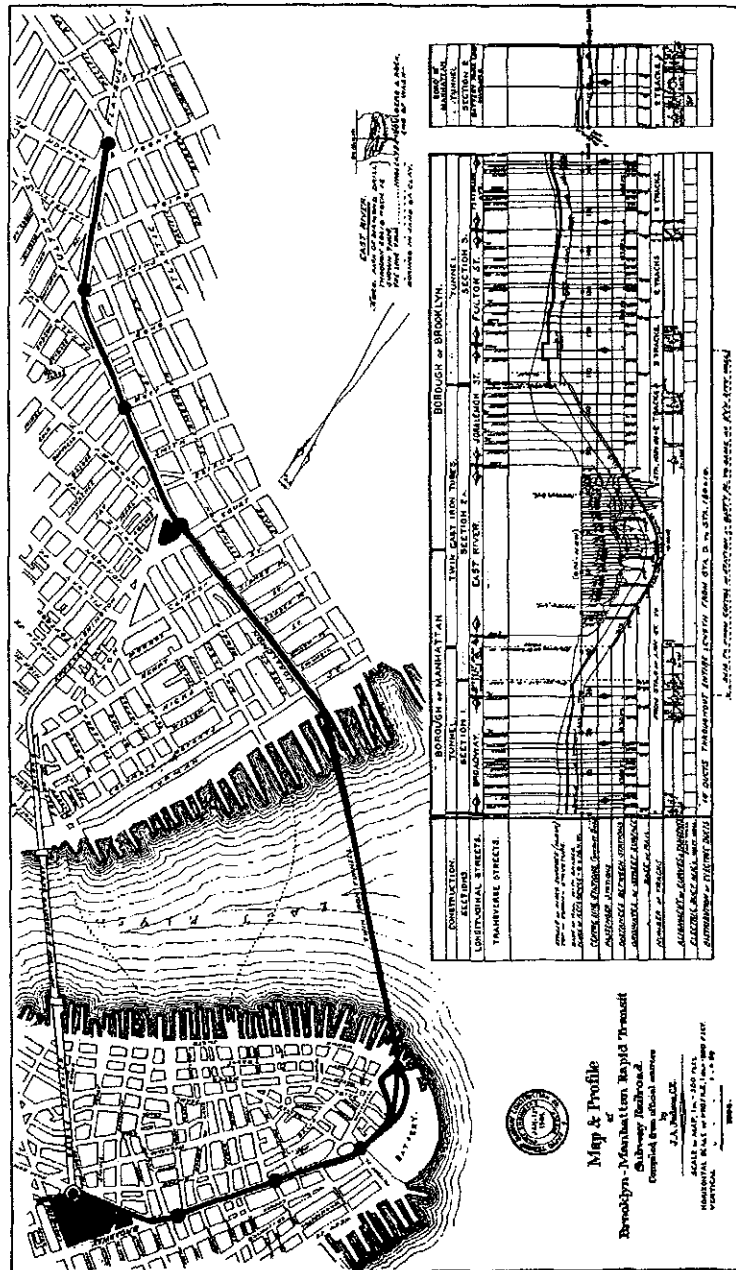
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF DIFFERENT TYPES OF CONCRETE
ARCH CONSTRUCTION AT STATIONS: FOR
CEILINGS AND SIDE WALLS.



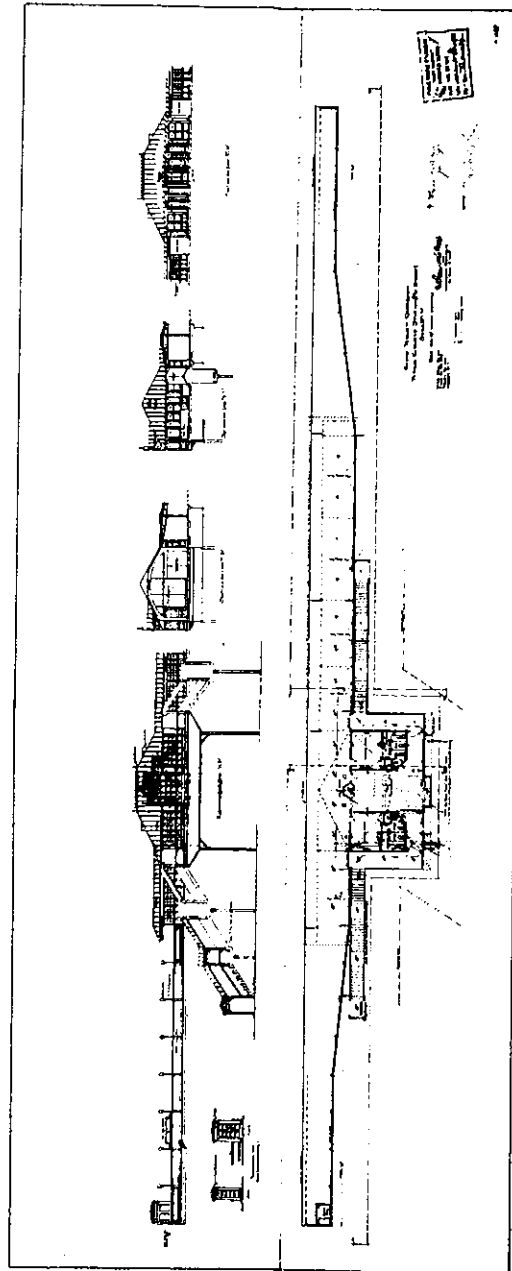
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: DIAGRAM SHOWING WEAR ON
RAILS ON VARIOUS CURVES.



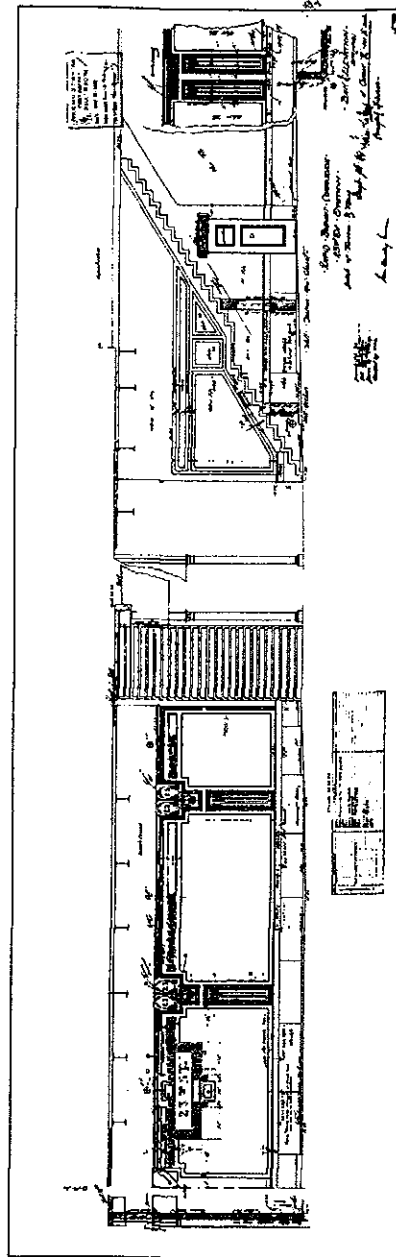
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: MAP AND PROFILE OF BROOKLYN-
MANHATTAN RAPID TRANSIT SUBWAY
RAILROAD. 1904.



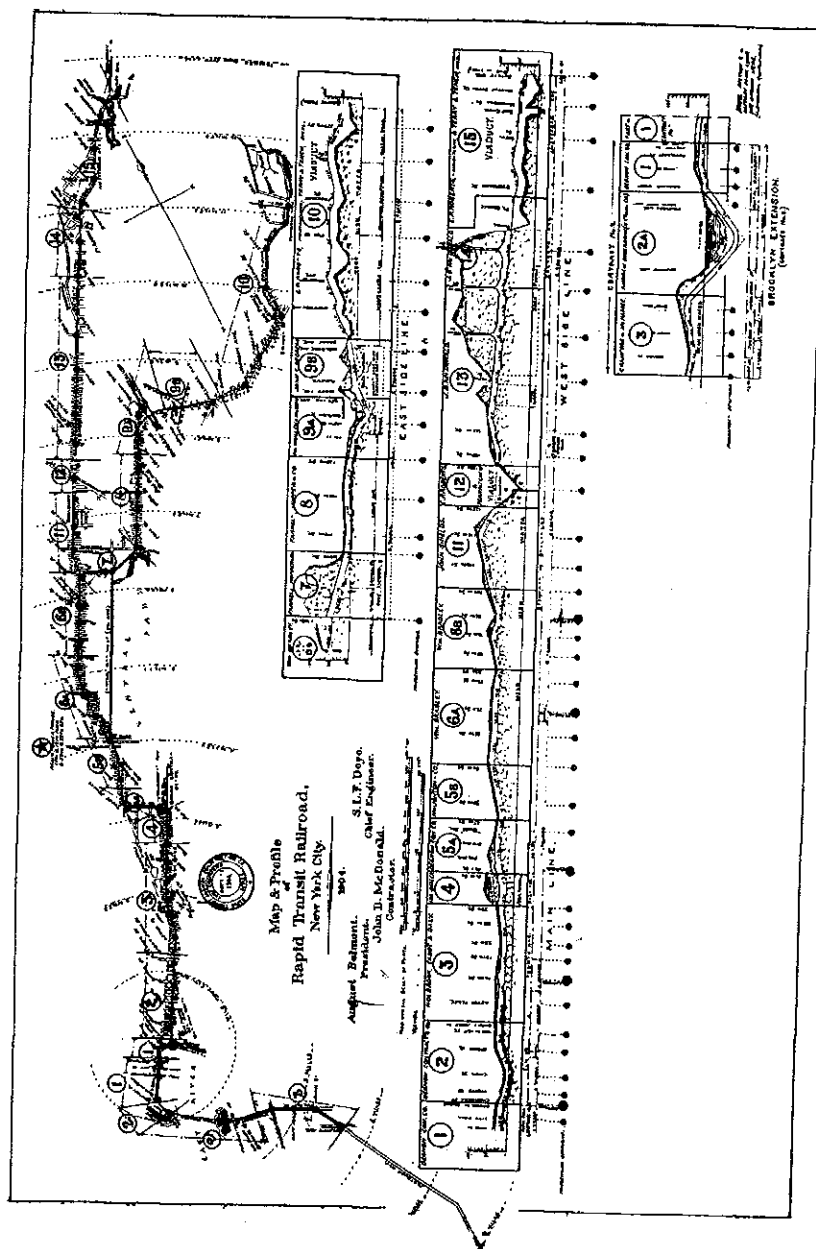
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: TYPICAL ELEVATED STATION.



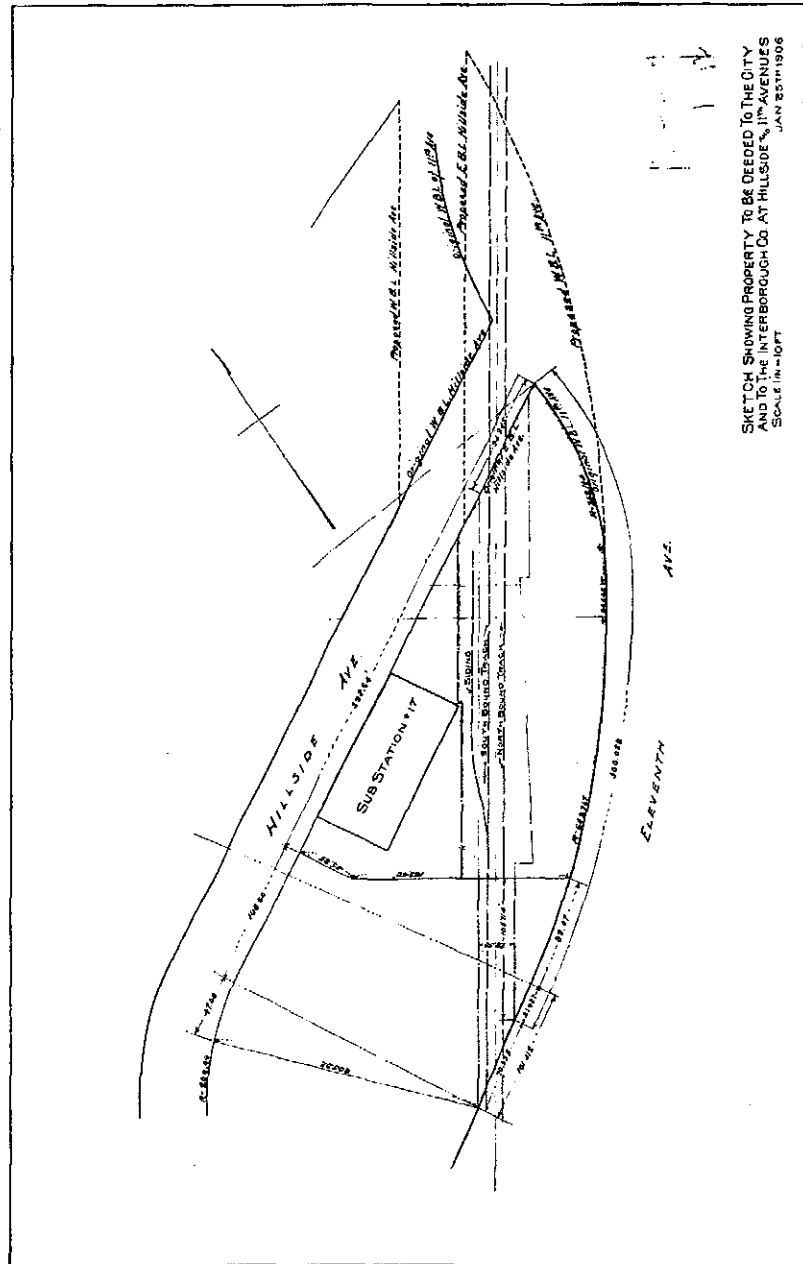
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: DETAILS OF 23RD STREET STATION.



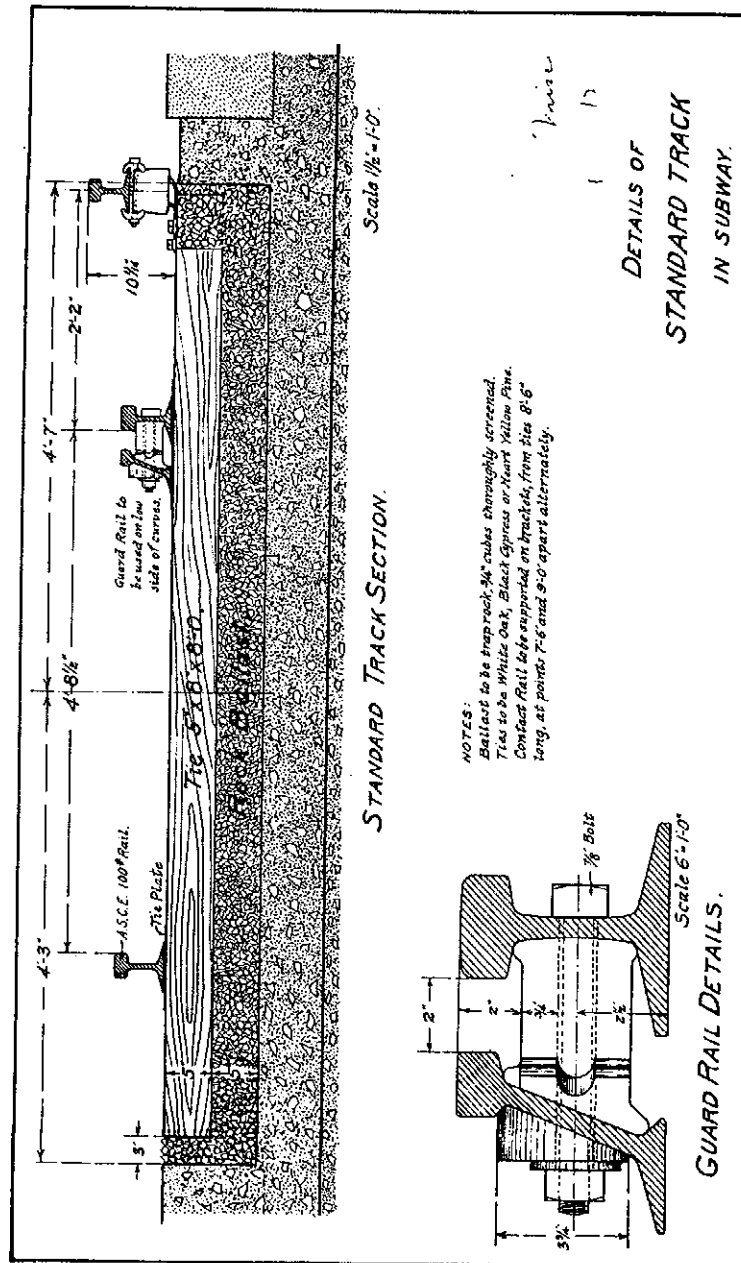
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: MAP AND PROFILE OF RAPID TRANSIT
RAILROAD. 1904.



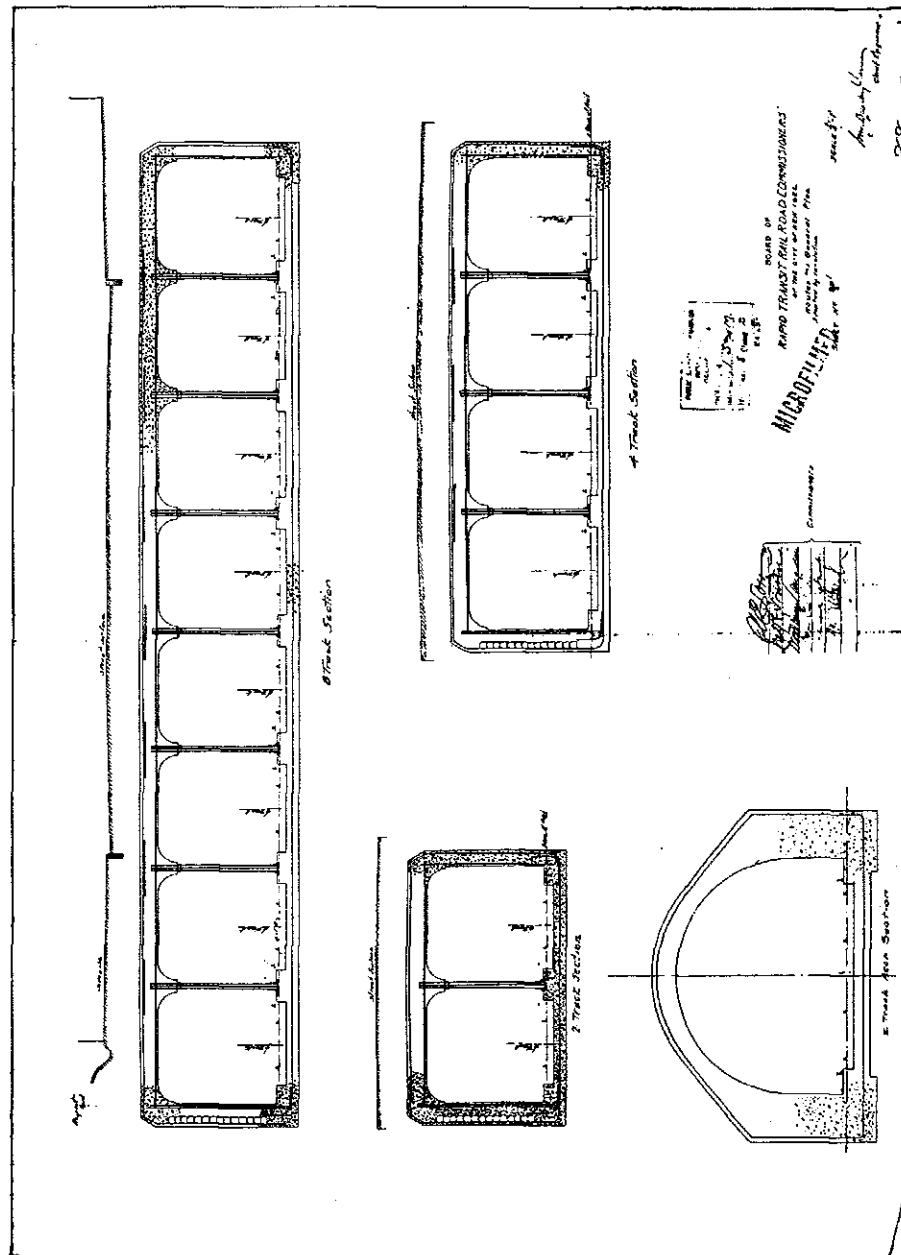
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING SHOWING PROPERTY TO BE DEEDED TO
THE CITY AND TO THE INTERBOROUGH COMPANY AT
HILLSIDE AND 11TH AVENUES. SHOWS LOCATION
OF SUBSTATION #17. 1906.



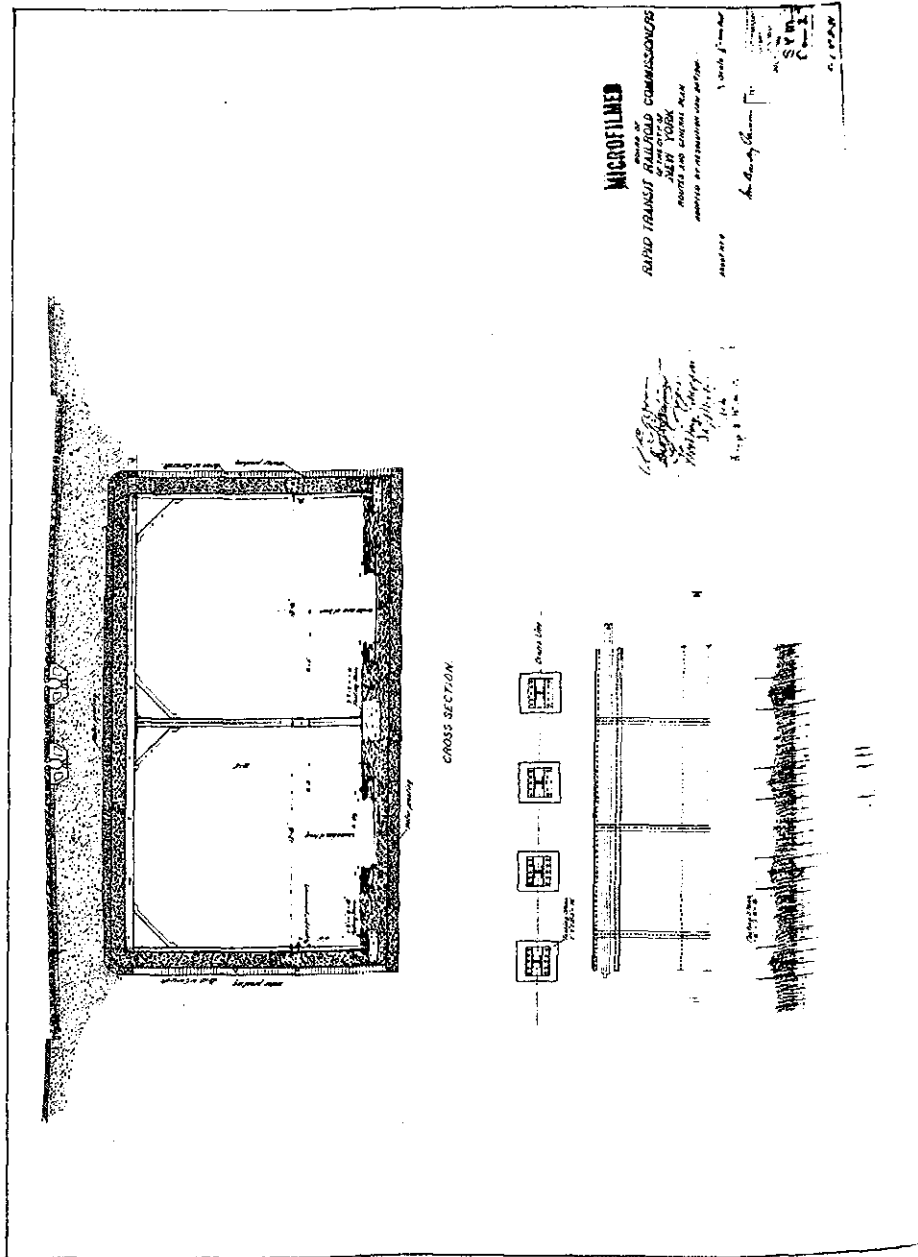
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: DETAILS OF STANDARD TRACK IN
SUBWAY.



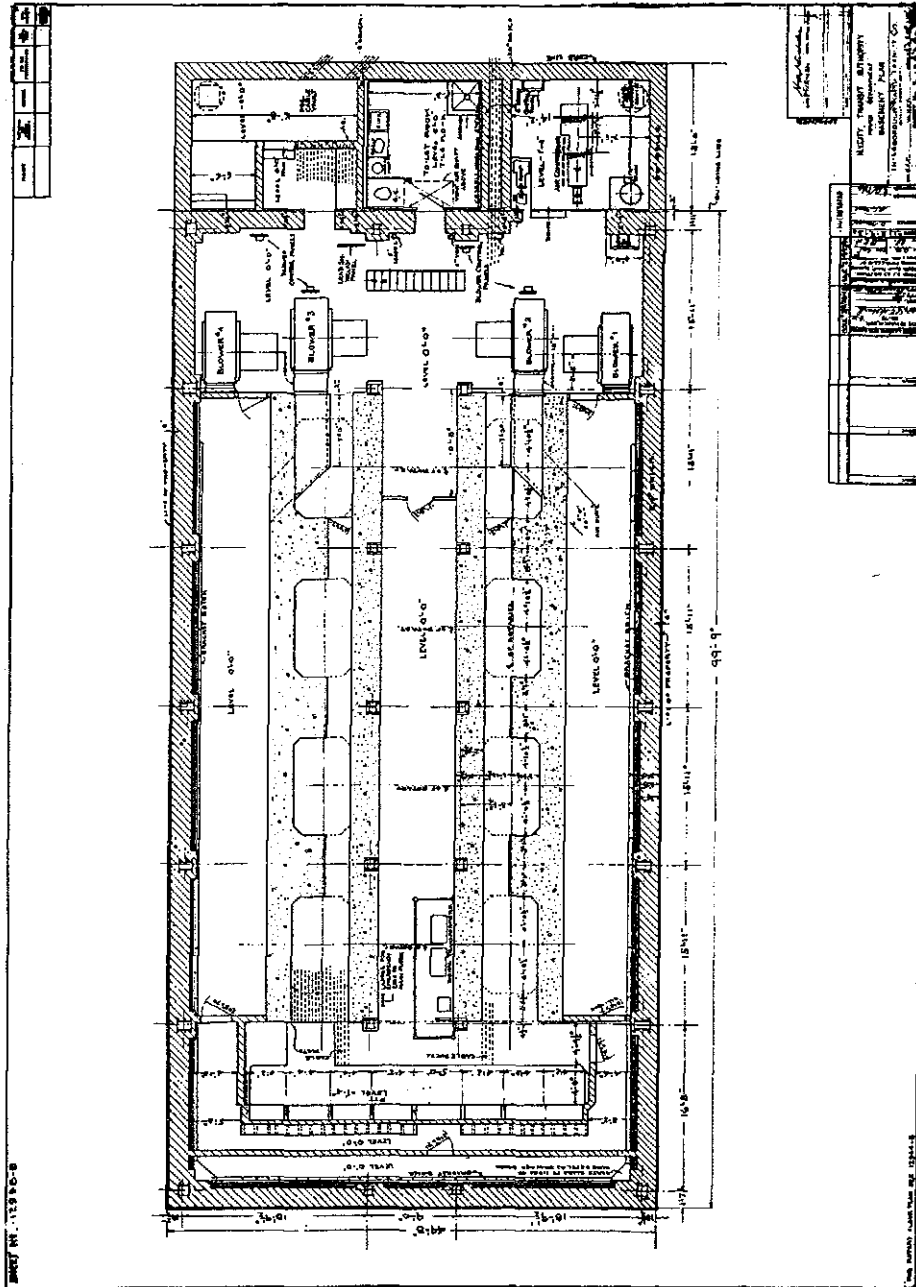
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
 DRAWING SHOWING 8-TRACK, 4-TRACK, AND
 2-TRACK STEEL SECTIONS, AND 2-TRACK CONCRETE
 ARCH SECTION.



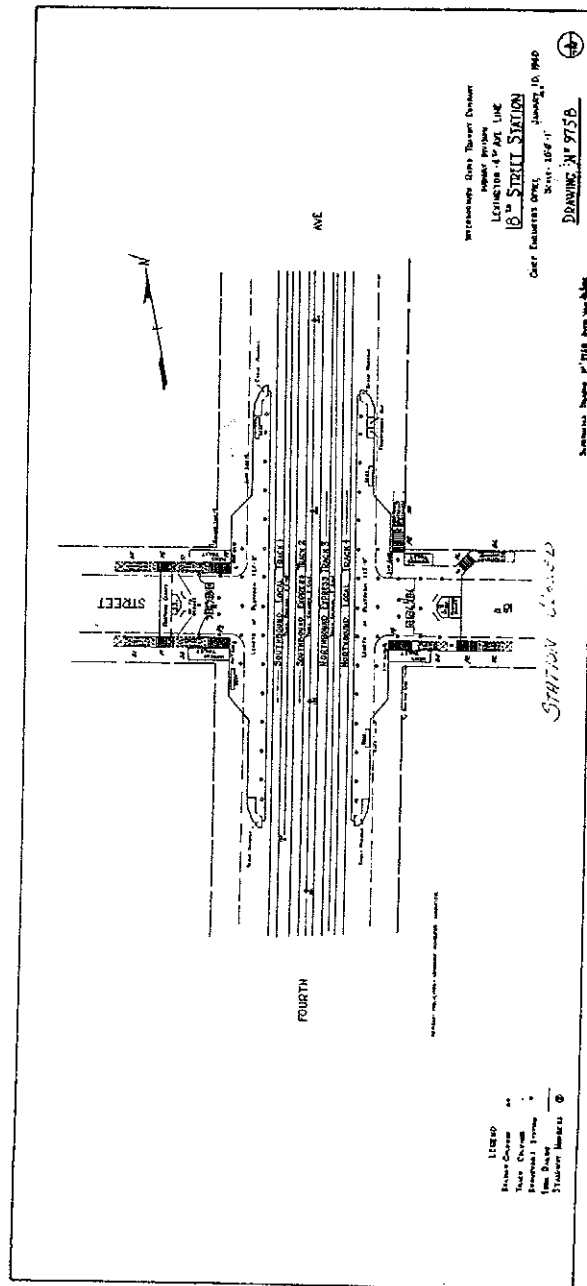
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING SHOWING CROSS-SECTION AND HALF-
PLAN OF 2-TRACK, STEEL SECTION OF SUBWAY.



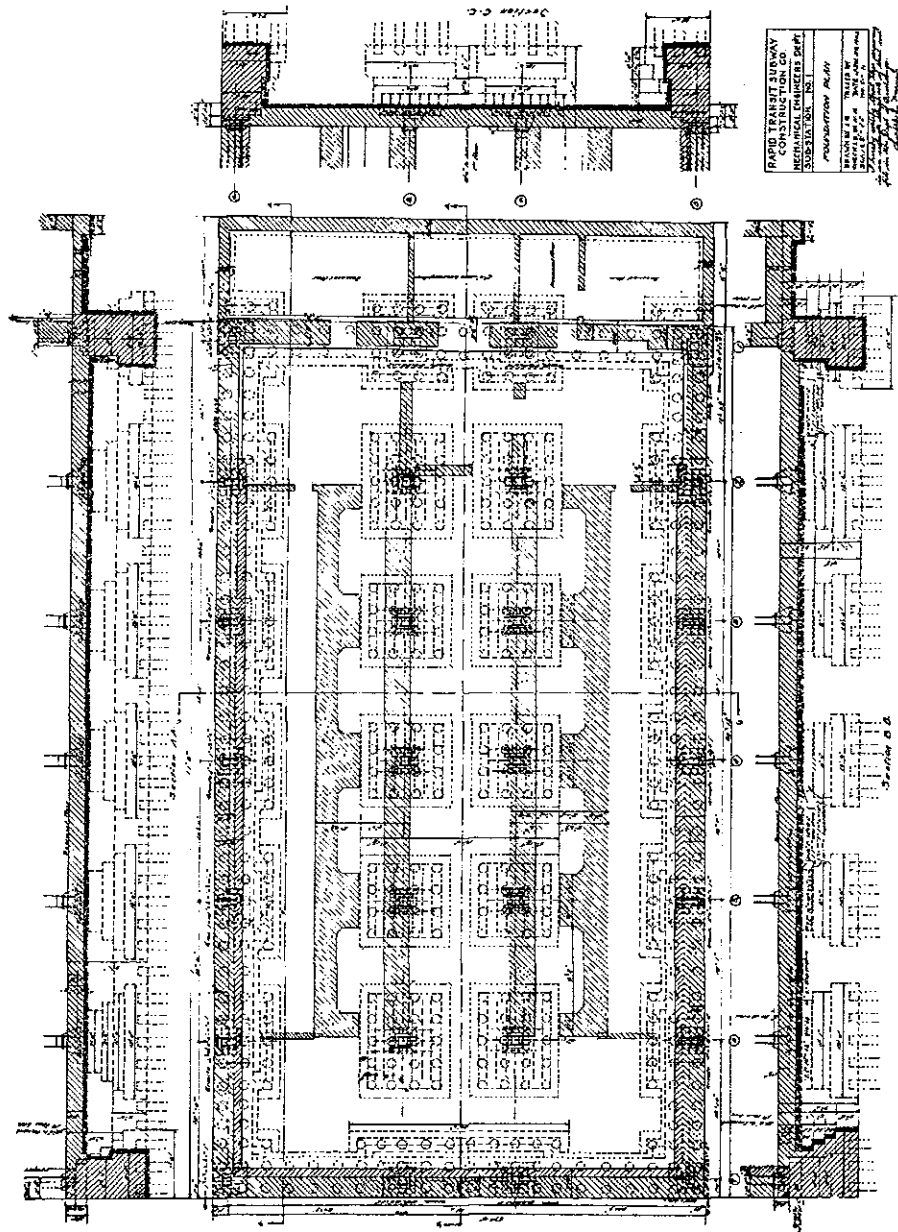
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING OF BASEMENT PLAN OF SUBSTATION.



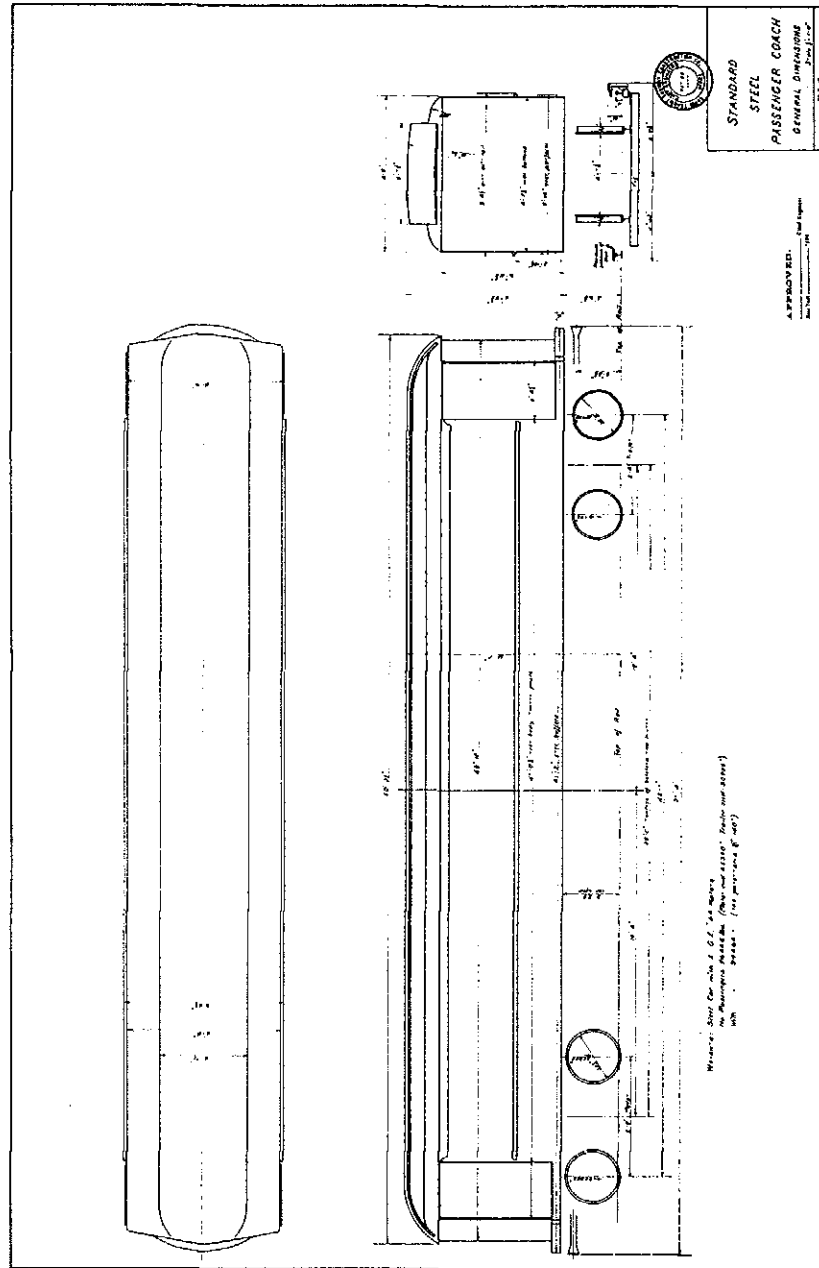
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: PLAN OF 18TH STREET STATION
ON LEXINGTON-4TH AVENUE LINE.



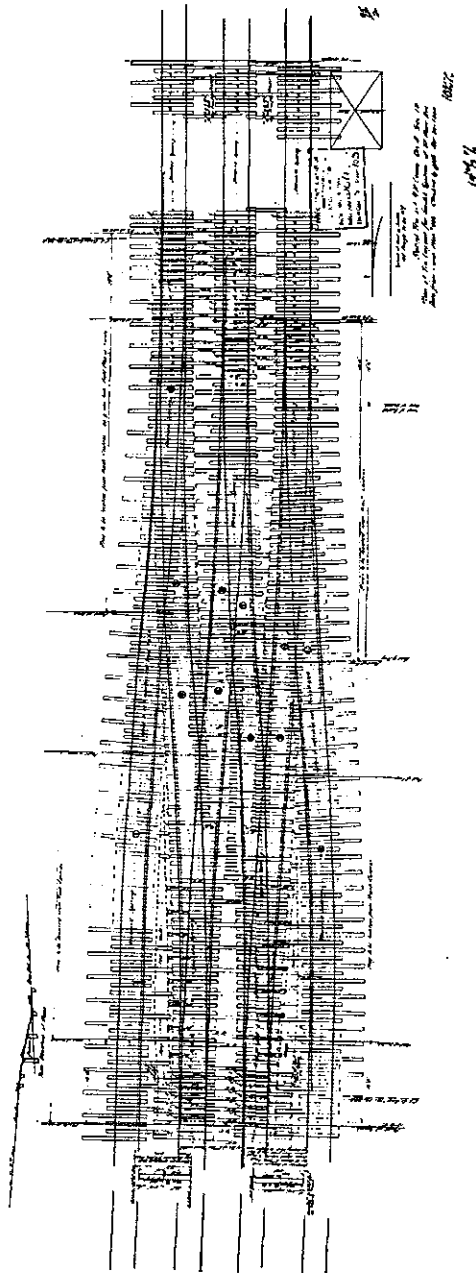
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
 DRAWING: FOUNDATION PLAN OF SUB-
 STATION #1.



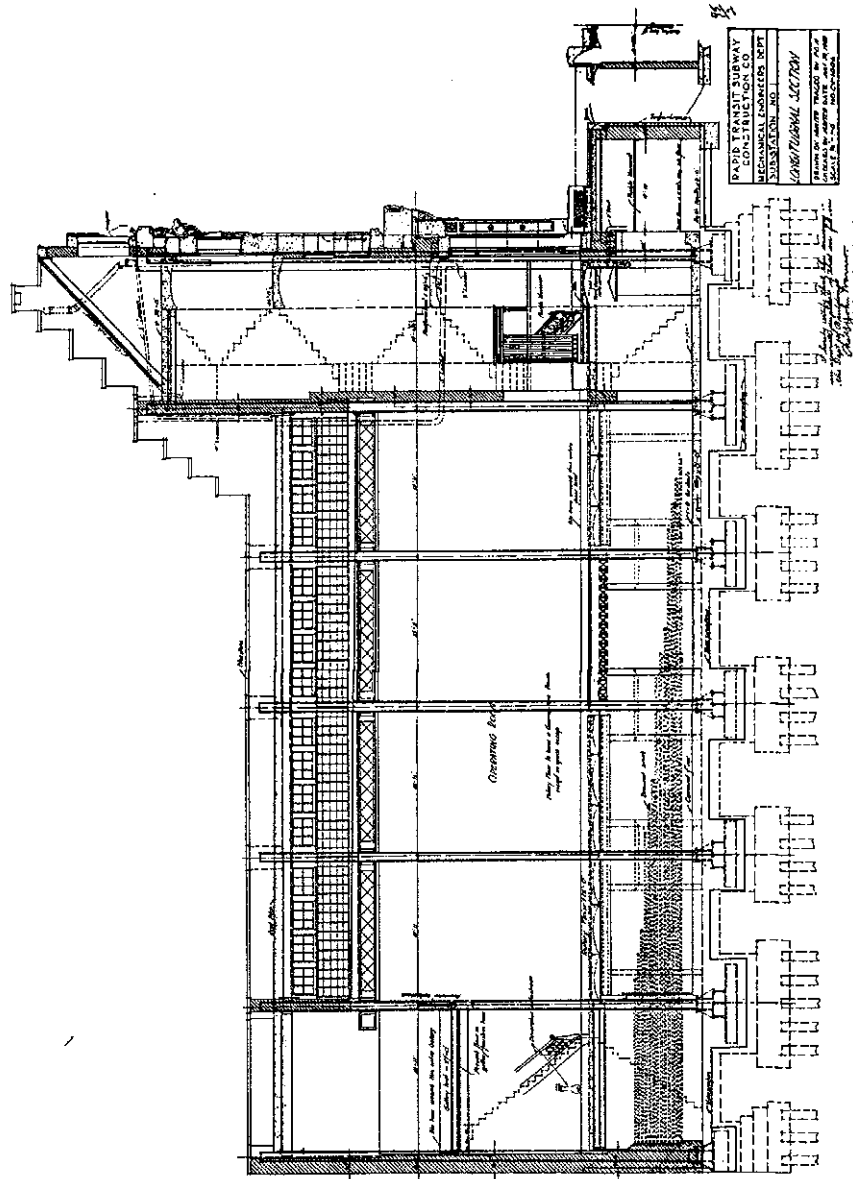
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: STANDARD STEEL PASSENGER
COACH. SHOWS PROFILES AND GROSS DIMENSIONS.



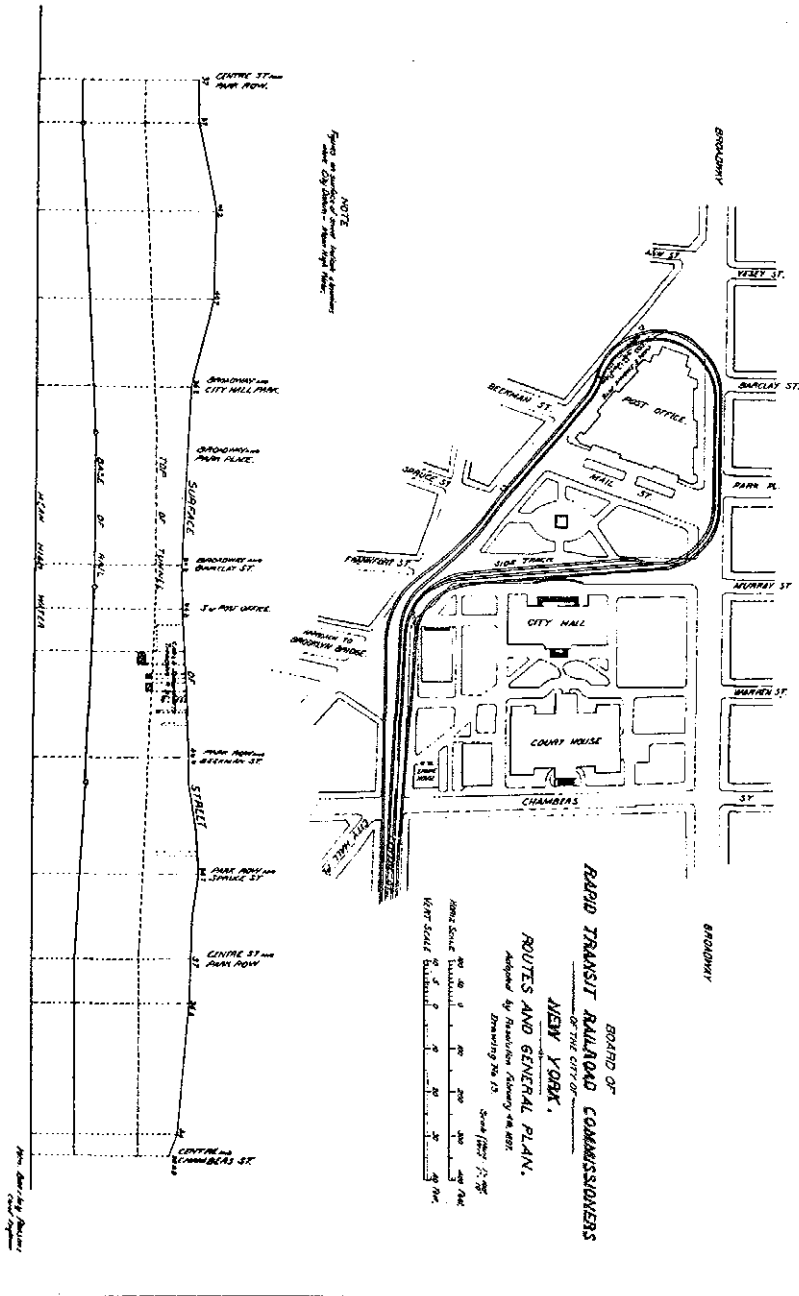
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: PLAN OF TIE LAYOUT FOR SWITCH
SYSTEM AT ST. ANN'S AVENUE. 1904.



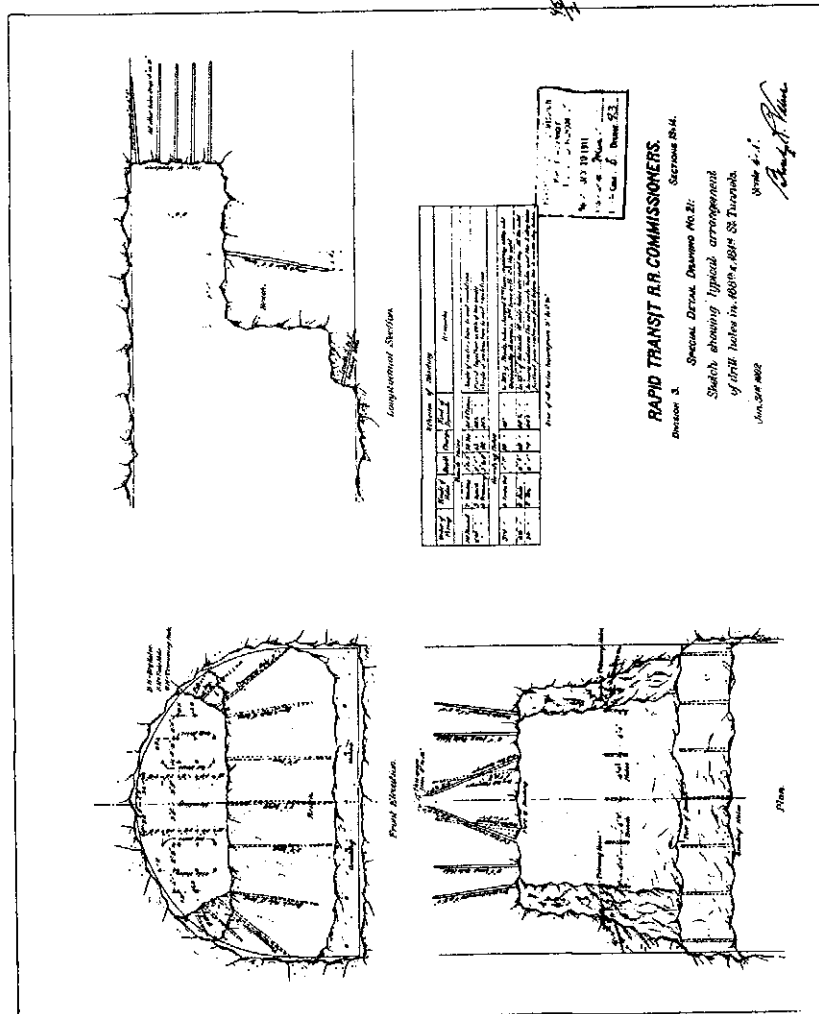
Photocopied courtesy of the New York City Metropolitan Transit Authority.

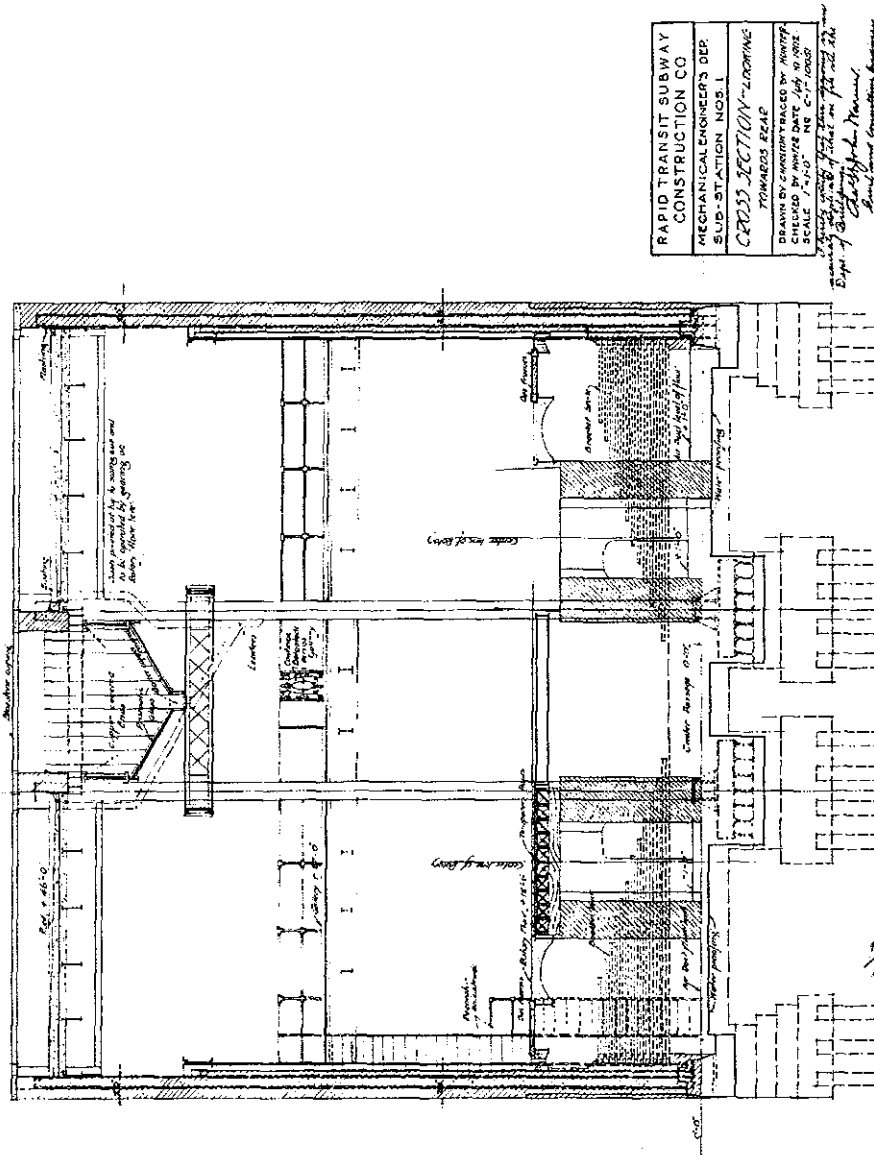
Photocopied August 1978. (MTA)
DRAWING: LONGITUDINAL SECTION OF
SUB-STATION #1.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: SHOWING PARTIAL ROUTE, PLAN
OF CITY HALL LOOP.



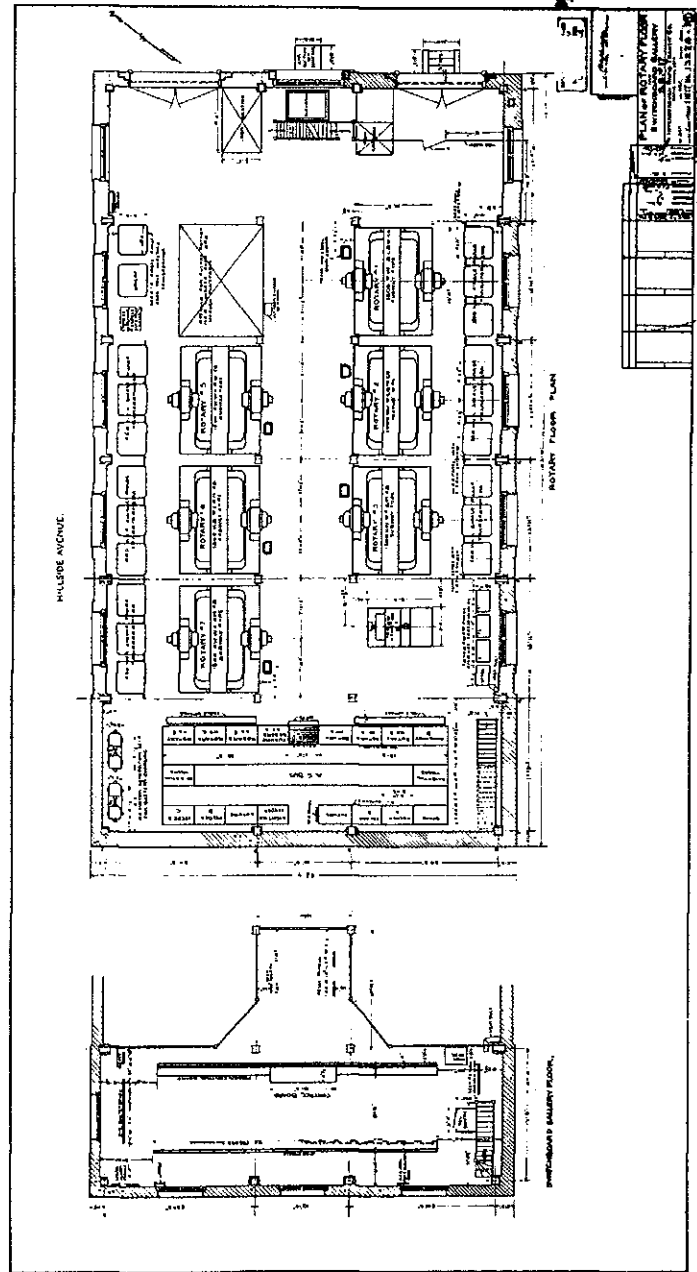


RAPID TRANSIT SUBWAY
CONSTRUCTION CO.
MECHANICAL ENGINEER'S DEP.
SUB-STATION NOS. 1
CROSS SECTION - LOOKING
TOWARDS REAR
DRAWN BY ENGINEER PAULS BY 10/1/27
CHECKED BY 10/1/27 DATE 10/10/27
SCALE 1"=10' NO. C-1-1000

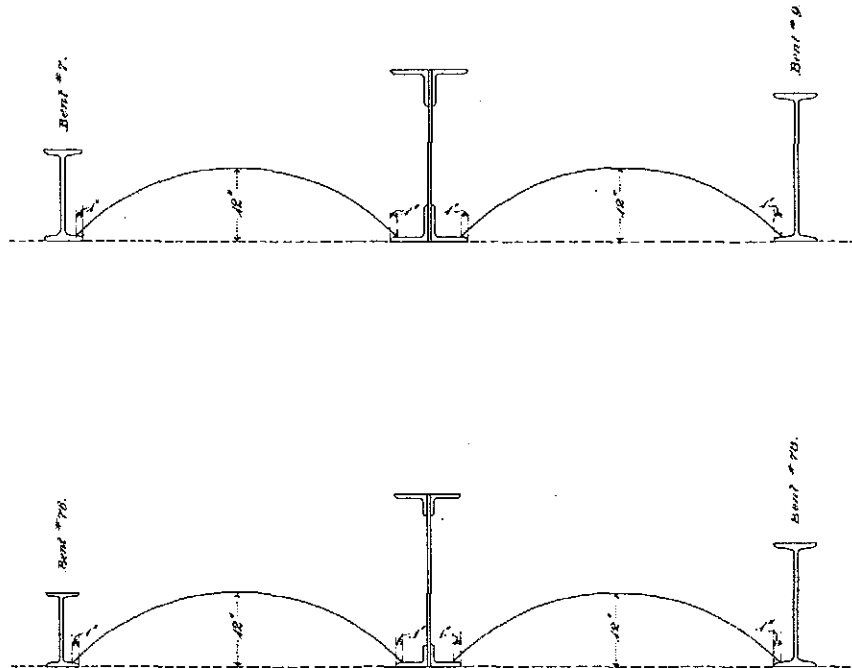
By J. J. Sullivan, Engineer
Pauls

Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: CROSS-SECTION OF SUB-STATION
#1. 1902.



Photocopied courtesy of the New York City Metropolitan Transit Authority.



RAPID TRANSIT COMMISSIONERS.
OFFICE OF 3rd DIVISION.

DESCRIPTION 110th St. Station.
Sections showing typical form of
Roof Arches.

SECTION No. 2. SPECIAL DETAIL DRAWING No. 423
DATE Feb. 12th 1902. SCALE 1"=4'
FILE A. B.

PUBLIC SERVICE COMMISSION
FIRST DISTRICT
RECORD ROOM

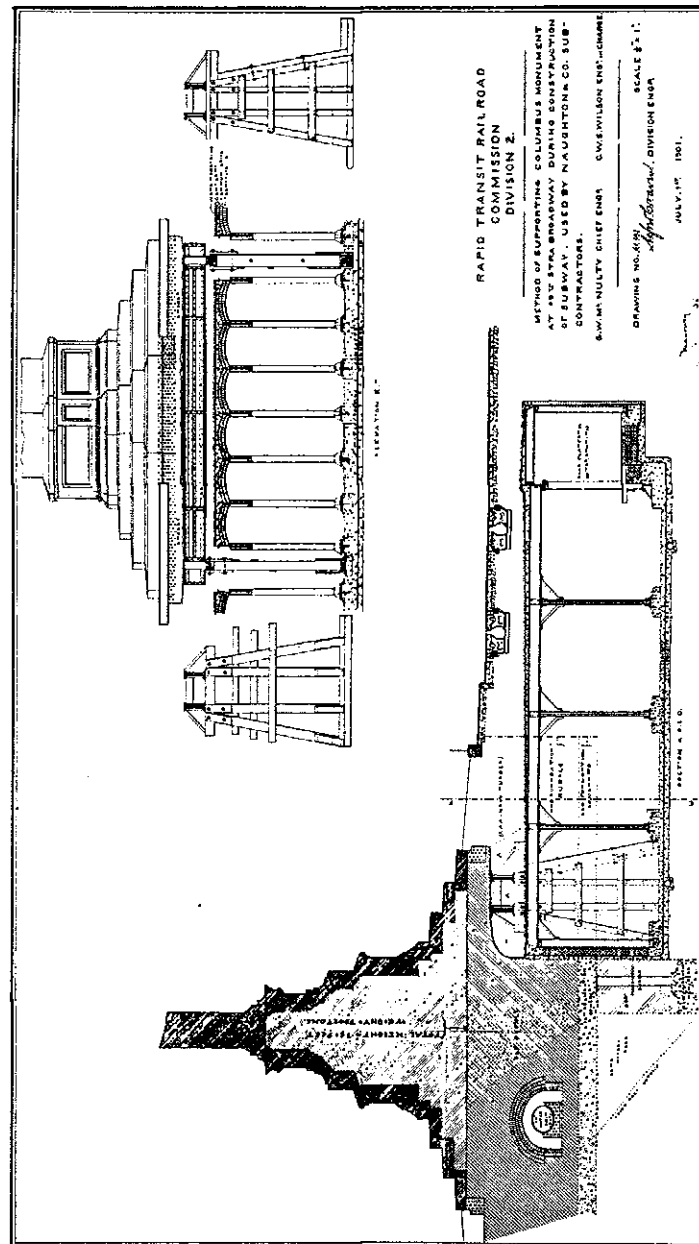
Rec'd DEC 15 1910
Index under 321.1
File in Case 2. Drawer 85

B. A. Valer

D. E.

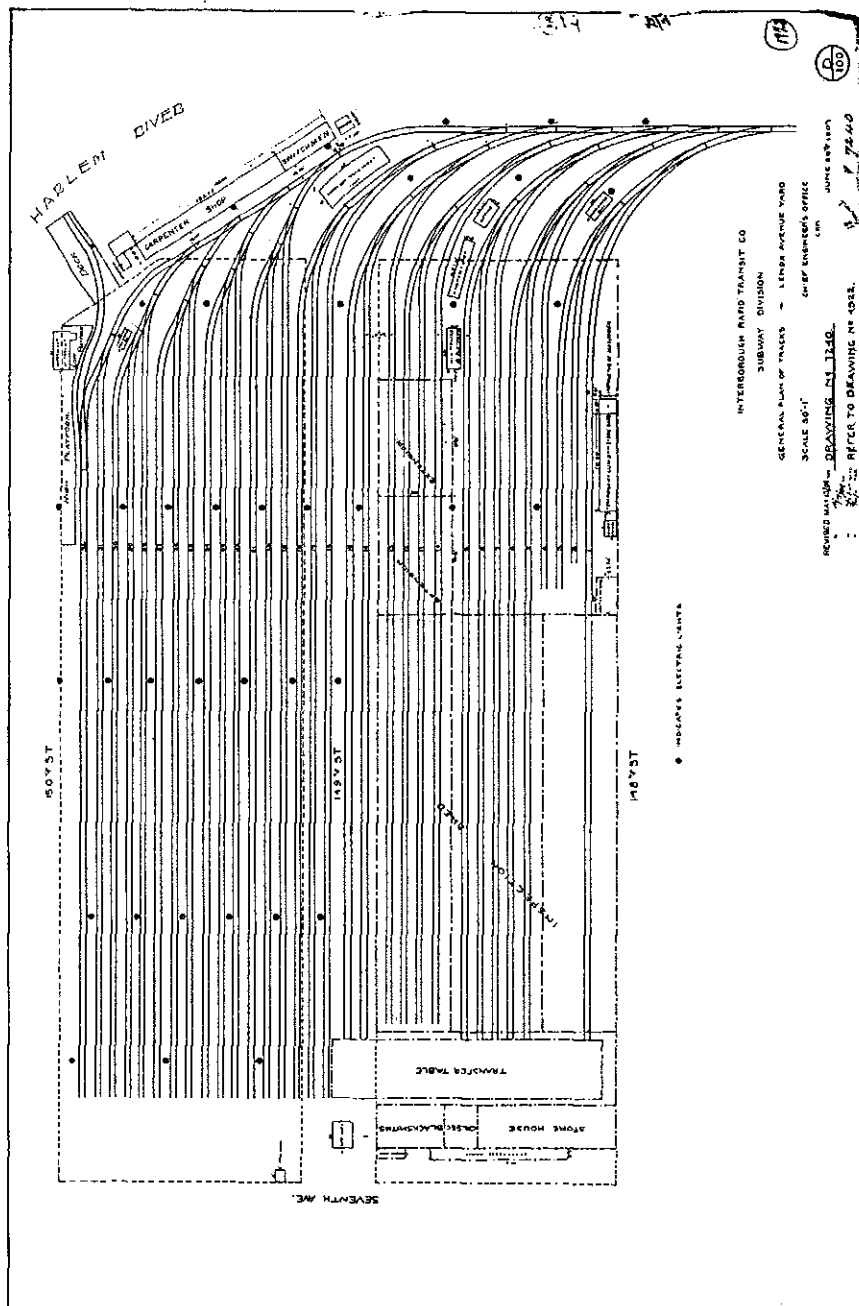
Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: SECTIONS SHOWING TYPICAL FORM
OF ROOF ARCHES.



Photocopied courtesy of the New York City Metropolitan Transit Authority.

Photocopied August 1978. (MTA)
DRAWING: METHOD OF SUPPORTING COLUMBUS
MONUMENT AT 59TH STREET. 1901.

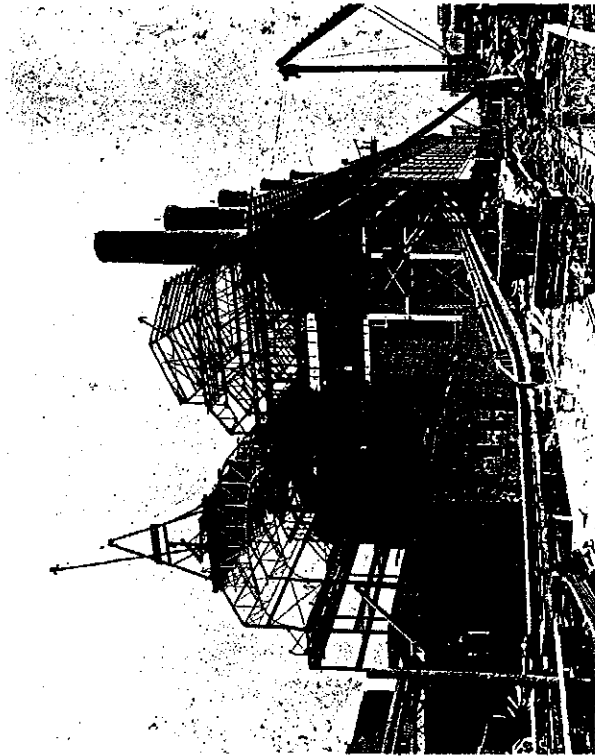


Photocopied courtesy of the New York City Metropolitan Transit Authority.

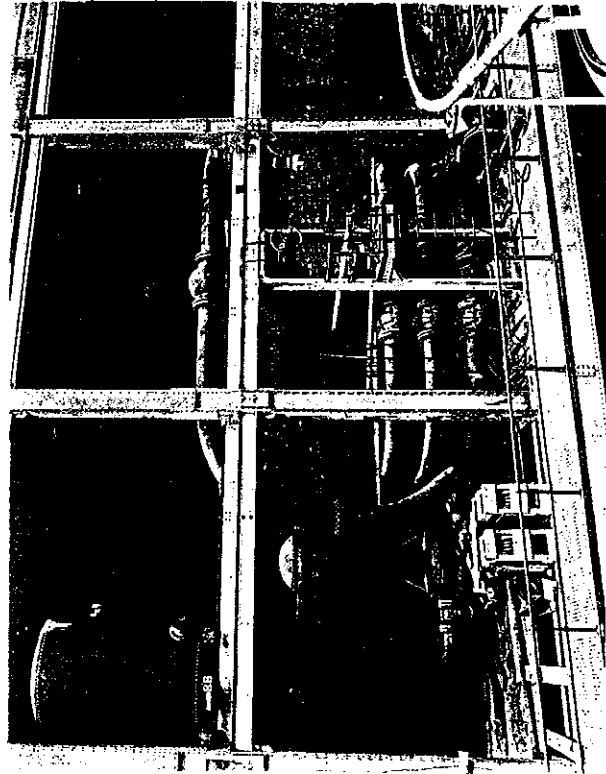
Photocopied August 1978. (MTA)
 DRAWING: GENERAL PLAN OF TRACKS--
 LENOX AVENUE YARD. 1907.



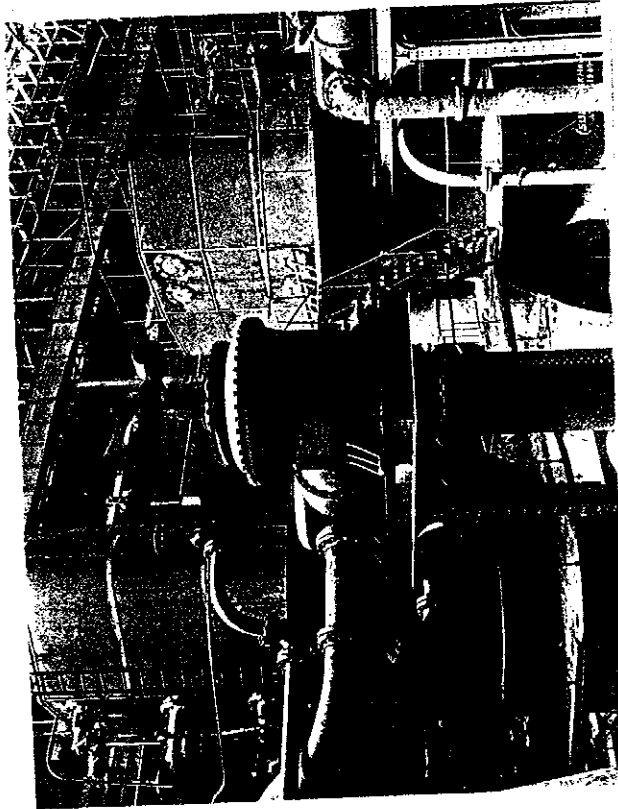
Photocopy of a print at the Museum of the
City of New York, August, 1978.
MAIN POWER STATION UNDER CONSTRUCTION AT
59TH STREET AND 11TH AND 12TH AVENUES. INSTALLATION
OF WESTINGHOUSE ALTERNATOR-GENERATOR, 1904.



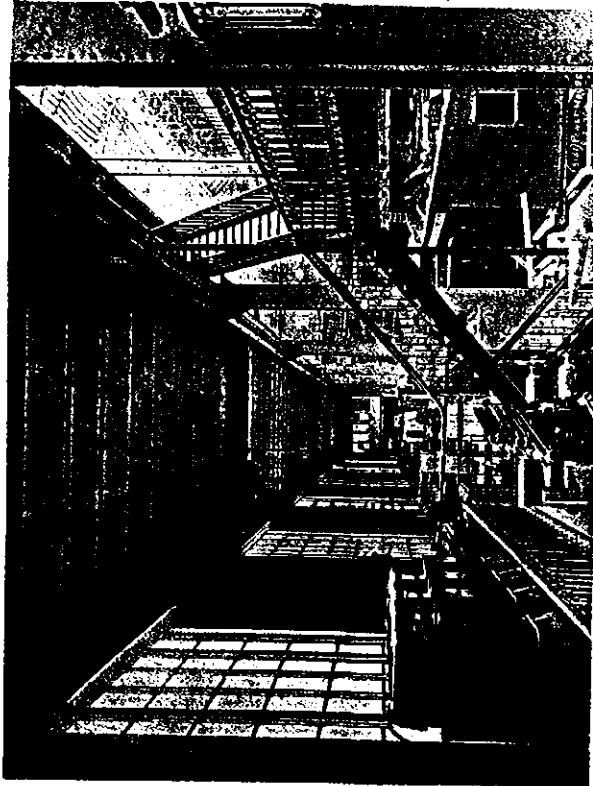
Photocopy of a print at the Museum of the City
of New York, August, 1978.
MAIN POWER STATION UNDER CONSTRUCTION AT 59TH
STREET AND 11TH AND 12TH AVENUES, 1902. NOTE
COMPLETED CHIMNEYS: ALSO SEPARATE STRUCTURAL
FRAMEWORKS FOR THE TWO HALVES OF THE PLANT.
VIEW LOOKS EAST.



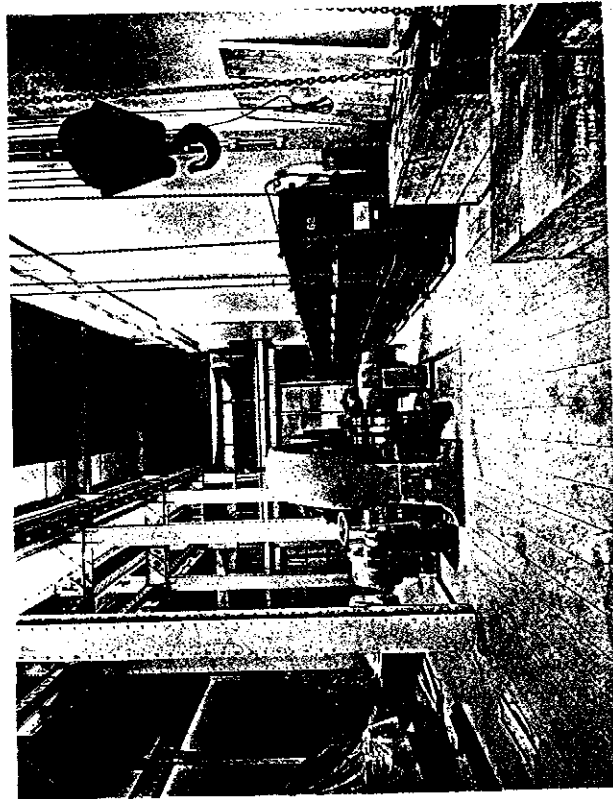
Photocopy of a print at the Museum of the City of New York, August, 1978.
MAIN POWER STATION AT 59TH STREET, 11TH AND 12TH AVENUES, CA.1904. STEAM PIPING FROM BOILERS TO STEAM ENGINES. THE LARGE PIPES LEAD DOWNWARD TO THE HIGH PRESSURE CYLINDER AT THE ENGINE: THE THREE HORIZONTAL PIPES ARE PART OF THE MANIFOLD SYSTEM.



Photocopy of a print at the Museum of the City
of New York, August, 1978.
MAIN POWER STATION, 58TH AND 59TH STREETS AND
11TH AND 12TH AVENUES, CA.1904. VIEW OF
ALBERGER JET CONDENSER UNIT BESIDE STEAM
ENGINE.



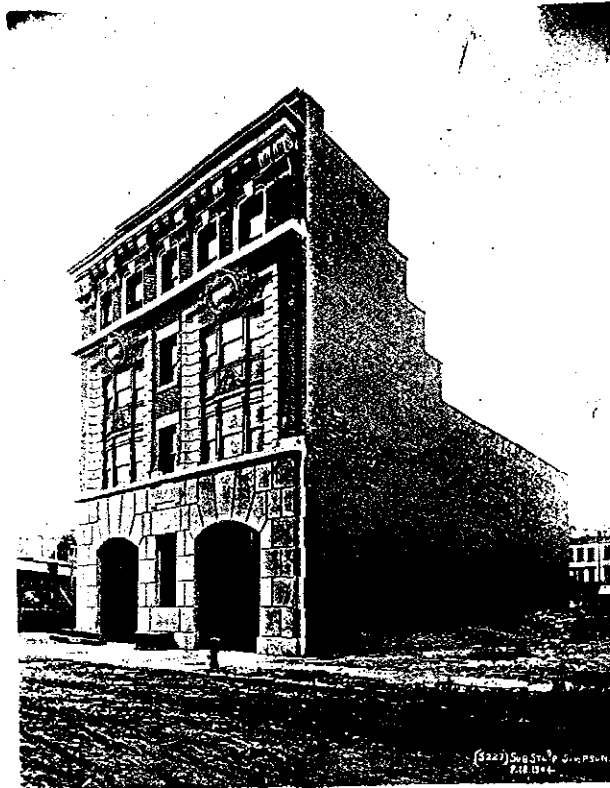
Photocopy of a print at the Museum of the
City of New York, August, 1978.
MAIN POWER STATION, 58TH AND 59TH STREETS AND
11TH AND 12TH AVENUES, CA. 1904. DECORATIVE
STAIRWAYS LEADING TO OPERATING ROOM GALLERIES.



Photocopy of a print at the Museum of the
City of New York, August, 1978.
204 WEST 96TH STREET SUB-STATION, 1904 VIEW
LOOKS SOUTH ALONG ONE ROW OF ROTORIES AND
TRANSFORMERS (ON SIDE WALL). NOTE HAND-OPERATED
CRANE IN FOREGROUND, RAISED GALLERY FOR
CONTROL BOARDS AT REAR.



Photocopy of a print at the Museum of the City
of New York, August, 1978.
SUB-STATION, 254 WEST 96TH STREET, 1904. VIEW
LOOKS WEST ALONG GALLERY. ON LEFT ARE BRICK
COMPARTMENTS, EACH HOUSING A D.C. FEEDER OIL
CIRCUIT-BREAKER, OPPOSITE THEIR RESPECTIVE
SWITCHES ON THE RIGHT.



Photocopy of a print at the Museum of the City
of New York, August, 1978.
1043 SIMPSON STREET SUB-STATION, BRONX, CA. 1905-06.
NOTE ITS ISOLATION IN RELATIVELY RURAL
SURROUNDINGS.